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# SCHOOL SCIENCE AND MATHEMATICS

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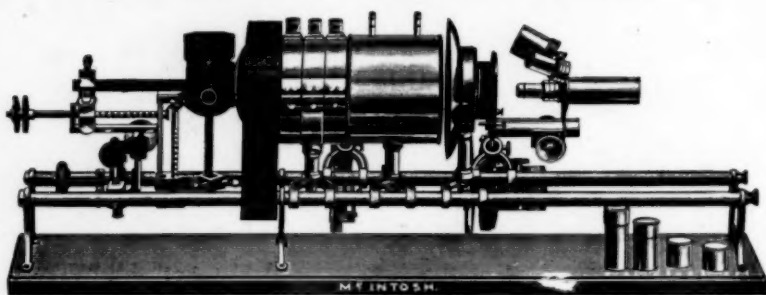
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VOL. XVII, No. 2

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## SOME RECENT ADVANCES IN PLANT PATHOLOGY.<sup>1</sup>

By L. R. JONES,

*University of Wisconsin, Madison.*

Plant pathology aims to add to human understanding along two lines: (1) the cause or nature of disease in plants; (2) the control of the diseases of cultivated crops. Rapid advances are being made in both. It would be impracticable, even if it were profitable, to attempt to summarize many of these in a half hour. Instead, I shall select certain illustrations to show the trend, being guided by the possible interests of the biology teacher.

Please note that in the first of these two lines we must deal with fundamental biological problems; in the second with the human relations of these.

### CONCERNING THE CAUSES OR NATURE OF DISEASE IN PLANTS.

There are no more complex and hence no more interesting problems in biology than those dealing with parasitism. Here we deal, not with a single organism, but with two, the parasite and the host, with life processes and problems interlocked. Even more puzzling to the pathologist are the diseases which are communicable, but with no discoverable parasite; "infectious" and "non-parasitic" are ideas hard to reconcile. All the skill of the plant physiologist is needed if we are to understand some of the commonest maladies which result directly from unfavorable environmental factors—food, water, light, temperature—to say nothing of possible toxic substances. To illustrate, we may cite certain recent advances in understanding the causes of the death and blackening of the internal flesh of potato tubers. The natural thought is that this betokens the presence of a parasite, and indeed there are at least three common parasitic diseases showing such symptoms, two fungous dry rots (*Phytophthora* and *Fusarium* spp.) and the

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<sup>1</sup>Read before the Biology Section of the Central Association of Science and Mathematics Teachers' at the University of Chicago, December 1, 1916.

bacterial wet rot (*Bacillus* sp.). But resembling these strikingly in symptoms are the "black heart" and "frost necrosis" troubles, due simply to improper temperature relations.

"Black heart" occurs at times in whole carloads of winter-shipped potatoes, where it is necessary to keep a fire in the car to withstand frost. Recent studies at the University of Wisconsin<sup>2</sup> have revealed the surprising fact that heating the potato tuber merely to blood heat for a day ( $38^{\circ}$ - $45^{\circ}$  C. for twenty to forty-eight hours) may be fatal to the interior tissues. It is an experiment which may be worth introducing into the plant physiology laboratory. The explanation seems to be that the gentle heating stimulates abnormally rapid respiration, which in turn so exhausts the oxygen supply as to kill the interior cells by asphyxiation.

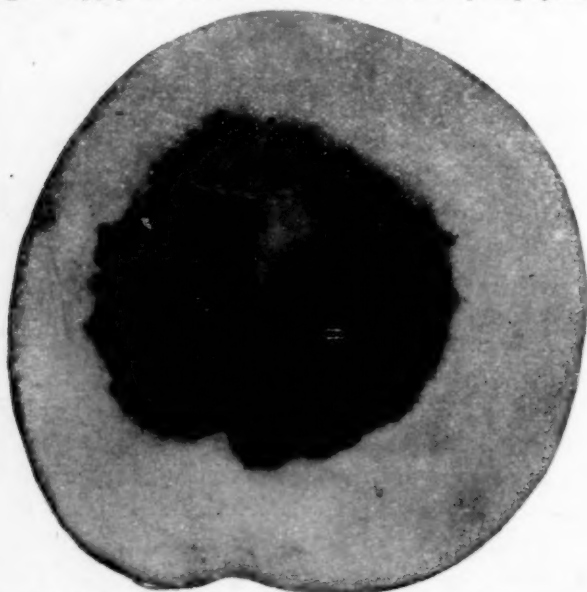


FIGURE I. BLACK HEART OF POTATO TUBER.

CAUSED BY HEATING AT ABOUT BLOOD HEAT FOR ONE DAY.

A counterpart to this, which also might be tried in the plant physiology class exercises, is "frost necrosis." We have long been puzzled by interior "fiber-blackening" in stored potato tubers, unassociated with any parasite. Search for the cause has shown that in some cases at least it is mild frost. It is a familiar fact that a thoroughly frozen potato is killed and will immediately collapse upon thawing, and it is also familiar that a potato is not so frozen until one passes below the freezing point of pure water. (Why?)

<sup>2</sup>Bartholomew, E. T., *A Pathological and Physiological Study of the Black Heart of Potato Tubers*. Centbl. Bakt. Abt. 2, 43:609-638. 1915.



But the surprisingly interesting thing is to learn that the interior tissues vary in susceptibility. To test this, subject the tuber to mild prolonged freezing temperatures (e. g.  $-2^{\circ}\text{C}.$ , five hours, or  $-1^{\circ}\text{C}.$ , nine hours, or  $-9^{\circ}\text{C}.$ , one hour) until gentle squeezing reveals the fact that frost crystals are just beginning to form within, and then hold it at normal storage temperature a day for the effect to become apparent. If, then, you cut it open, you will find evidence of several things of interest to the plant physiologist as well as the pathologist. The tissues which have been killed by the frost, blacken. (Why?) The occurrence and distribution of this blackening may vary: (1) the individual tubers may not behave alike, some being more sensitive than others; (2) the two ends of the tubers may not behave alike, the "stem" end being more sensitive than the "bud" end; (3) the two chief tissue regions may not behave alike, the vascular being the more sensitive. As a result, in many cases, when such a tuber, which appears normal externally, is cut across, the flesh is permeated with a network of black lines, mapping out the dead vascular regions, whereas the starchy parenchyma appears white and sound. Most surprising, perhaps, is the fact that in such cases of interior "frost necrosis" the buds or eyes may not be killed.



FIGURE II. FROST NECROSIS OF POTATO TUBER.

NOTE THAT THE VASCULAR REGIONS DIE AND BLACKEN FIRST.

Recent advances in understanding the cause or nature of a parasitic disease which seem most interesting and significant have come from Smith's work on the bacterial crown gall disease—or, as he prefers to term them, "plant cancers."<sup>3</sup> There are many types of vegetable gall or cancerous enlargement. Often these re-

<sup>3</sup>Smith, Erwin F., Brown, Nellie A., and McCulloch, Lucia, *The Structure and Development of Crown Gall: A Plant Cancer*. U. S. Dept. Agr. Bur. Plant Indus. Bul. 255. 1912.

sult from insect stings, as oak leaf galls, sometimes merely from continued wounding, or abrasion, as when two limbs chafe together. A certain infectious gall, termed crown gall, widespread on nursery stock, has proved due to a bacterial parasite. The parasitic bacteria apparently exist within the living host cell, stimulating it to abnormally active growth and division. This leads not merely to local tumor or cancer-like growths, but even to tumor strands, which bore their way through the interior of stem or petiole from the point of origin to remoter regions where new local tumor growths or cancerous lesions appear. The striking analogies which Smith has pointed out between these plant tumors and animal cancer are at least suggestive to students of human cancer and especially pertinent to those who, although as yet baffled in their search for a parasitic causal agent, still hold to this hypothesis. Smith's latest advance is in securing tumor formations by bringing bacterial products, or indeed certain other chemicals, into contact with the veritable plant tissues, and he suggests that the causal factor exciting such tumor growths may be merely a slight disturbance of the local osmotic relations.

But if we are to cover the topic, we must let these examples suffice to illustrate some of the more fundamental aims, and turn to the other questions.

#### CONCERNING THE CONTROL OF PLANT DISEASES.

It is the nature of man to wish "a specific" for every ailment, whether of his own body, his beast, or his crop. It has required laws to protect him from racial suicide with patent medicine "dopes," and I sometimes think that the harvest time is approaching for the "quack doctors" of plants. And how many American plant cultivators have come to believe that there must be some specific spray needed whenever their crops fail? As a matter of fact, only a portion of crop failures are due to specific diseases, and only a small portion of these are controllable by sprays. In their place, especially with fruits, sprays are highly useful and more spraying should be done, but spraying is in general costly and temporal, even where effective. While improvements are being made each year in the compounding and use of sprays, the chief advances in plant disease control point to better things. Seed disinfection is being increasingly used and has a wider range of usefulness than spray remedies, especially with garden and field crops. Here again, advances each year are leading to modified solutions or new applications.

Spraying and seed disinfection are indeed only partial and local attempts at solving the more fundamental problem of *plant sanitation*. With parasitic diseases of plants in general, as with the epidemic animal diseases, the most important thing, so far as practicable, is to destroy the infectious material in order, by removing such sources, to forestall the epidemic. We are only beginning to realize the importance of this in its human relations, still less in its relations to our crops. Bolley of North Dakota is showing that the lessening wheat crops from continued culture are not so much due to exhaustion of soil fertility as to the resultant accumulation of seed and soil parasites. Herein lies the strongest argument for rational rotation with cultivated crops, and the sequence in such rotation must be governed by the possible host relations of the parasites. Thus Fred has shown that the failure of cotton following cow peas is due to the killing of the cotton seedling by a fungus (*Rhizoctonia*) developed on the cow pea. With the cherry leaf spot, where spraying is the chief reliance, Keitt has recently found that, since the parasite overwinters on the dead leaves alone, by destroying these in advance of spring infection the disease can be controlled without spraying. "Cleanliness is next to godliness" hung as a suggestive motto before the pupils of a primary school I once attended. If I could find that antique chromo now, I might be tempted to display it as a watchword to be fixed in the minds of those who are to lead in the control of plant diseases.

But the most encouraging of all advances in plant disease control are where disease resistant strains are being secured. The evidence is rapidly accumulating that plants of the same species or even of the same variety may vary widely among themselves in susceptibility to a given parasite.

Advantage has been taken of this by Orton in securing strains of cotton and cow pea resistant to the wilt disease, which was crippling the chief crops of the South. This same idea is sustaining the courage of Freeman and others in their persistent endeavors to perfect a commercially satisfactory wheat immune to rust. One can hardly overestimate the economic significance of progress along these lines. The possibilities have recently been illustrated in Wisconsin in connection with the *Fusarium* or "yellows" disease of cabbage. This is due to a soil parasite which persists indefinitely, following its introduction. This has made continued cabbage culture impossible on land where form-

erly it was the most important crop. Scattered over even the "sickest" field, however, healthy plants occur (Figure III). (Why?) Selections of the best types made from such in 1910 were used as mother plants, the seed so secured replanted on "sick" soil, selections and seed growing repeated, and in 1914 the results were as follows:



FIGURE III. DISEASE RESISTANCE OFFERS THE BEST CONTROL.

WISCONSIN HOLLANDER CABBAGE, SELECTED FOR DISEASE RESISTANCE ON THE RIGHT. AT THE LEFT COMMERCIAL SEED WAS USED. THE SOIL WAS ALL EQUALLY "SICK." WISCONSIN CABBAGE MEN ARE NOW GROWING THEIR OWN SEED BY SELECTING MOTHER PLANTS FROM SUCH FIELDS.

RESULTS, RESISTANT "WISCONSIN HOLLANDER" CABBAGE, 1914.

	Diseased.	Lived.	Headed.	Av'ge Wt.	Yield per A.
Control	82.0%	49%	24%	2.6 lbs.	2.0 tons
Selected	1.5%	100%	98%	5.5 lbs.	18.7 tons

Let us not raise false hopes. Not often may we secure results as surely and quickly as this. But the fundamental idea is sound, and whatever time and effort are necessary may well be given to secure such ends. It is simply the familiar principle of the "survival of the fittest" applied to the control of disease in plants. What natural selection has done in the past, human selection should, as need arises, improve upon. Man has been given dominion. Plants and animals are plastic in his hands if only he studies and follows nature's laws.

## HOW A SWING IS WORKED—A LECTURE EXPERIMENT.

BY FREDERICK A. OSBORN,  
*University of Washington, Seattle.*

Everyone is familiar with swinging by alternately crouching down and standing up in a swing. The process of gradually *increasing* the *amplitude* of the swing is brought about as follows: The start is usually made by jumping back from the ground, and then crouching down while the swing is moving from A to B (Figure 1). At B, the swinger stands up until he reaches C. On the return, the swinger crouches from C to B, and stands up from B to A.

It occurred to the writer some time ago that a lecture experiment to illustrate this process of swinging would be of interest, and the simple apparatus here illustrated and described resulted.

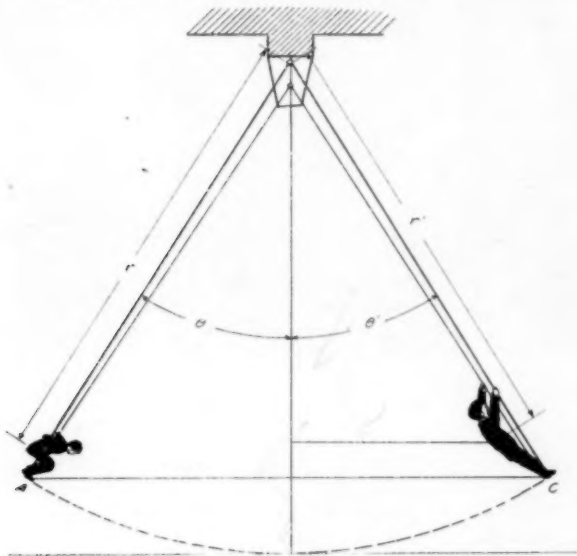


FIGURE 1.

The swing (Figure 2), one meter long, has mounted on the seat a small electromagnet (M) with a movable iron rod for a core. To the upper end of this rod is fastened a brass cylinder of about 100 grams mass. The cylinder is held one and a half inches above the magnet by a spring (S). Wires from the electromagnet are fastened to heavier wires which serve as the swing supports, and connections are made from the upper ends of these wires to a four volt storage battery. A key of the push but-

ton type is mounted on the base, and enables the operator to energize the electromagnet at will.

The swing is given an initial amplitude of three or four inches, and then as it leaves the A position the circuit is closed by the button, and the brass cylinder is pulled down toward the magnet a distance of about half an inch. This represents the crouching position of the swinger. As the swing passes the B position, the

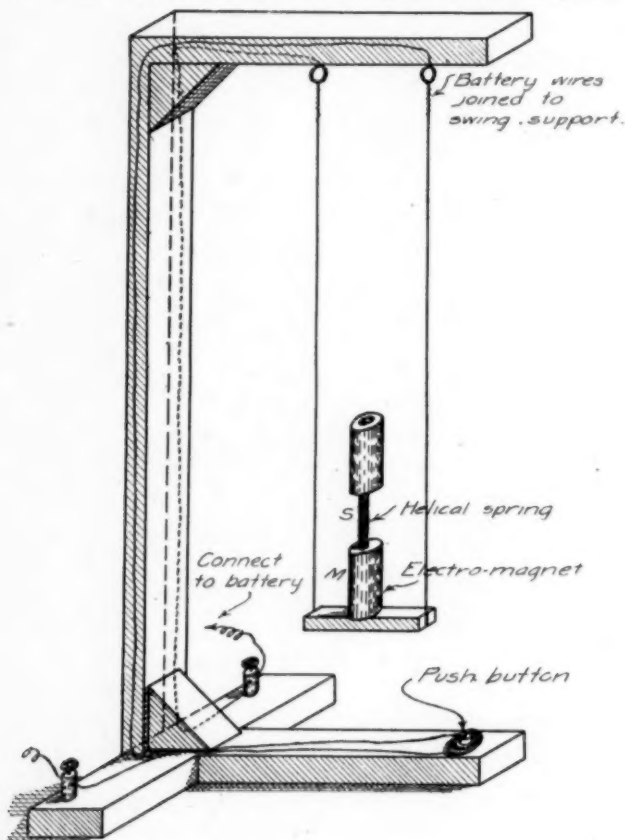


FIGURE 2.

circuit is opened, and the coiled spring raises the brass cylinder to its original position. On the return from C to B, the circuit is closed, and opened at B as before.

Some little practice is required to operate the push button at the proper instant, but when this has been obtained, the amplitude of the swing can be nearly doubled in fifteen to twenty vibrations.

In the actual case of swinging, the energy necessary to maintain and increase the amplitude of the swing is furnished by the



swinger in changing his position from crouching to upright. The kinetic energy of the swinger has increased, and as he stood up his potential energy also increased. He had to *do more work* in bringing his body *in* nearer the axis of rotation. This is easily seen if one considers the *increase* in the force necessary to pull a *revolving* mass in closer to the center.

In the electrical swing, the energy is furnished by the current.

The equations giving the kinetic energies, and the increased angle of swing, are of interest.

Let  $W$  represent the weight of the swinger,  $k$ , his swing radius about the axis of suspension when crouching from A to B, and  $k'$ , when standing up from B to C. The distances of his center of gravity from the axis are  $r$  and  $r'$ , in the two positions, and  $\theta$  and  $\theta'$ , the angles of swing on the AB and BC sides, respectively.

The kinetic energy at B coming from A is

$$E = \frac{Wk^2\omega^2}{2g} \text{ and at B on leaving}$$

after standing up is

$$E_1 = \frac{Wk_1^2\omega_1^2}{2g}.$$

The angular momenta are the same, so

$$Wk^2\omega = Wk_1^2\omega_1.$$

Therefore,

$$\frac{E}{E_1} = \frac{\omega}{\omega_1} = \frac{k_1^2}{k^2} \text{ or } E_1 > E.$$

The angle of swing,  $\theta_1$  is given by:

$$\sin \frac{\theta_1}{2} = \frac{k}{k_1} \sqrt{\frac{r}{r_1}} \sin \frac{\theta}{2}.$$

#### PROSPECTS OF OIL AND GAS IN NORTHERN OKLAHOMA —GOVERNMENT GEOLOGIST MAKES REPORT.

The work of locating places where oil and gas are likely to be found by drilling is a task for painstaking and scientific geology. Although geologists can not positively determine whether oil and gas can be found in any region, they can locate the geologic structures—the rock arches and domes—which have a great influence on the accumulation of oil and gas. For this reason, most of the large oil companies now employ geologists to guide them in leasing and in locating exploratory wells.

The United States Geological Survey, Department of the Interior, has a corps of trained geologists working throughout the country to obtain information that will assist in developing our oil and gas resources, but their work, unlike that of the geologists in the employ of oil and gas companies, is done for the benefit of the country as a whole, and the landowner as well as the oil man can make use of the information they obtain.

**THE STUDY OF THE FLOWER IN THE FALL.**

By C. H. SACKETT,

*Soldan High School, St. Louis, Mo.*

Any course in botany which does not give the pupil a very definite knowledge of the flower is missing an opportunity. The modern tendency has been to flit lightly over this subject to avoid the suspicion of being old-fashioned. The writer bears testimony to his own first interest in botany being aroused by the study of the flower, and the accusation cannot be made that this was due to the character of the course he first took. Today, to the young pupil, plants are "flowers," and this current misconception is good evidence of the first appeal to him of the flower.

Granting this fact, why should not the course begin at once with the study of the flower? The value of the work will depend entirely upon the character of the flowers selected for use. By all means, the thorough study of a very few flowers is much to be preferred to an incomplete study of flowers so modified as not to be usable, except in part. The larger and prettier the flower, the better. Why start off in the fall studying weeds? The pupil inherits a natural contempt for them; postpone the study a few weeks.

It, to be sure, is more difficult in the fall to secure the best material; there is not the wealth of trilliums one can find in the spring. The locality must suggest the actual forms studied. The writer's attention was called a few years ago by a fellow teacher to the value of the sedum, or stonecrop, found not uncommonly used as a second border plant in flower beds. The flower, though unfortunately small, is remarkable in the regularity of its parts. Except for occasional aberrations, especially among the stamens, there are five separate sepals, petals, stamens, and carpels. Some will object to teaching the carpel. The pupil will be quite sure to meet the word in his text, and ask for information; anyhow, it is no more difficult to teach than the poly- and synpetalous corolla—though one would be foolish to teach those adjectives unless he has rather advanced pupils and has a wealth of time. Teachers often use the words "pistil" and "carpel" synonymously. If the carpel is considered in the same relation to the pistil that the petal is to the corolla, that is, if the carpels are considered separate or "united" in the same manner petals are, the situation is simple. The study of the flower necessarily introduces a number of new terms, hence let the pupil learn a few new nouns, but why burden him with the euphonious adjectives? This flower, then, is an excellent one for the pupil to use to determine what the calyx,

corolla, stamens, and the parts of each of these are. Since the carpels are quite small, it is not wise to call attention to any other parts of the pistil. The parts to be identified in the entire flower as used by the writer are limited to ten, a number that ought not to stagger any pupil. These parts are—calyx, sepal, corolla, petal, stamen, filament, anther, pollen, pistil, and carpel.

This flower is well followed by the petunia, which is always available. Here the typical pistil is seen with its customary three parts. The carpels are here "united;" so also are the petals. There is no occasion, then, for confusing carpel and pistil, for no one confuses petal and corolla. The fact that the stamens are adnate (but do not use the word) to the corolla gives splendid opportunity to emphasize the fact that flowers are quite individual, and what is true of one may be quite different in details from another.

A third flower, easily obtainable, that lends itself, in addition, to problems of pollination, is the verbena. *Plumbago* or leadwort is a good substitute. A pupil by this time readily identifies the parts he has previously found, and has begun to notice the repeated occurrence of the parts in 5's. Now is the time to emphasize the remarkable fact that there is a great division of flowering plants, and be sure to abbreviate it to dicots, in which the flowers almost universally bear out this number, at least in some of their parts.

Next, study a monocot. The trillium is ideal, but in the fall a good form is found in the gladiolus. Here the opportunity should not be missed of examining a cross-section of the ovary. Let the pupil cut one himself, but by all means have one cut by yourself with a razor and mounted under some kind of a microscope of small magnifying power. Here the pupil gets a definite idea what ovules are; in the previous flowers, the ovaries have been too small to justify any study of their interiors. In this section, the pupil also learns how most accurately to determine the number of carpels in a pistil. The symmetry of the monocot flower is also of course evident.

Now, for a climax, and it should not be shrunk from, is the study of a composite. The very best one is the single dahlia, but a cosmos or a wild sunflower is good. It is better not to study a composite at all than to study a very small one. Pollen grains of the dahlia are spinose; in fact, those of the *Compositæ* are inclined to be more or less elaborately sculptured. Certainly the pupil should have a view of them under a compound microscope.

The above five flowers will have given a very logical introduc-

tion to flowers. A further study of others will run the risk of being tedious, and unless in a purely supplementary comparative way is hardly advisable, for there is too much else more significant that ought to be taught.

Nothing has been said about the laboratory notebook; that is an individual matter with the teacher. The writer has drawings made but no descriptions written. One table can concentrate all the facts of all the flowers. It is cruelty to insist on long descriptions of facts which a pupil can easily give in a recitation, but which are written and read with great tediousness.

And now comes, as a grand climax, a very candid explanation of fertilization. To fail to make a strong point of this is to miss the chance of taking advantage of the pupil's natural and innocent interest in the flower to teach its real meaning and unfold the mysteries of the necessary preliminary events that must occur in the reproduction of a plant, and the relationship that such a process suggests of plants to animals. This can be done with the help of diagrams, charts, or lantern slides. Mounted slides will rarely be of much use, but a little living evidence is easily furnished by germinating some pollen grains in a five or ten per cent cane sugar solution. Some pollen dusted into a few drops of the solution on a culture slide, or an ordinary slide kept where the liquid will not evaporate, will show good pollen tubes in about twenty-four hours or less.

Following the flower, one naturally studies fruits and seeds, and now it is high time to give the course a more physiological turn.

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#### USE OF DIATOMACEOUS EARTH IN SUGAR REFINING.

Diatomaceous earth, which is made up of remains of minute aquatic plants, is a light, earthy material resembling chalk or clay. The hardness, the minute size, and the angular shape of its grains make it an excellent metal-polishing agent, and heretofore it has been largely used as an abrasive in the form of polishing powders and scouring soaps. Of late, however, according to the United States Geological Survey, Department of the Interior, the uses of diatomaceous earth have been considerably extended. It is used by sugar refiners for filtering or clarifying; as an insulating packing material for safes, steam pipes, and boilers; and as a fireproof building material. In the United States it is used in the manufacture of records for talking machines. In Europe it has been used in preparing artificial fertilizers and in the manufacture of water glass, cements, artificial stone, paper, sealing wax, fireworks, papier-maché and other articles. A total of 4,593 tons of diatomaceous earth was produced and sold in the United States in 1915.

**TEACHING SEASONS.**

BY ROBERT M. BROWN,

*Rhode Island Normal School.*

From time to time there come through the mail circulars which advertise planetariums, sun discs, season apparatus, and a great variety of similar contrivances. These are extremely interesting inventions, and their versatility is amazing. A planetarium will illustrate clearly seventeen different items of human knowledge concerning the earth, the sun disc will explain seven, and a season apparatus will teach twelve facts relating to the earth as a whole, easier than one can do it by an hour's talk. Particularly alluring is a little device which shows on the earth the line between day and night for any day of the year, so that by rotating the globe one can easily ascertain the lengths of day and of night for any spot on the earth at any time during the year. It has, in addition, a whole array of accomplishments. The sun is a very small one and the earth a very large one; its belt to rotate the earth almost always slips, but the principle is there; the machinery is obvious; and when it is in full operation it takes a multitude of hands to manipulate it and to keep it on the table. It is a fair question to ask whether a simple piece of apparatus which illustrates clearly a single phenomenon is not better than one which attempts so much. Of course, one recognizes in reading the list that the seventeen different items which the planetarium will illustrate are not seventeen independent ideas; at the same time, there is for the immature mind too much complicated machinery; or symbols which divert the mind from the truth; or conditions which outstrip in importance some of the results in these pieces of apparatus. This is not theory but the result of experimentation. The "device which shows the day-and-night line" has been used more than others in these experiments with pupils of grammar and college grades and with teachers, and one of the generalizations of the outcome of a large number of trials reads that, while theoretically the apparatus clarified the ideas concerning the length of day and night, really it could not be used to answer a question only by those who had some previous knowledge of the cause of the differences.

There has been in the last few years a remarkable awakening concerning the teaching of mathematical geography, and many of the items of the elementary books of earlier days are now relegated to later and maturer years. There has been left for



the beginners in geography the gnomon and the globe, the simplest pieces of apparatus. The gnomon or upright stake is used to observe the length of the shadow cast by the stake, and thus to note the apparent northward and southward journeys of the sun. The globe illustrates the rotundity of the earth, its rotation, the inclination of the axis, and the resulting effects. But after all is said about various helps in teaching, it is the teacher that makes the apparatus helpful or confusing, and mathematical geography has been the bane of many teachers. There are good arguments against teaching any mathematical geography in the lower grades, and generally these arguments are based upon the failures of a teacher or a group of teachers in handling the subject. "Unless the interest and the curiosity of the pupils can be aroused, this subject should be omitted" might be a rule to be applied to many items in the course of study, but it should be rigidly enforced in the mathematical geography of lower grades.

A teacher debated whether or not to use the gnomon as an aid in teaching seasons. After some consultation, she was persuaded to leave the answer open and experiment with her class. One day she fastened on the window sill an upright stake which cast a shadow on the floor of her room. When the sun approached the short shadow time, she left her class, made a record on the floor and obtained the short shadow line. The next day she verified it. Without any comment to the class, she began to record shadow lengths on the floor. The pupils watched the process, became interested, helped the teacher make the records, observed the shadow increasing until January, then begin to decrease, and finally began to ask questions to learn what it was all about. Then the teacher knew that it was a proper time to teach the lesson. The minds were prepared to receive it and profit by it. Two evils, lack of preparation and lack of time to absorb, are apparent in the ordinary teaching of mathematical geography. A subject appears in the textbook or in the course of study in a certain place; when the subject is reached, the teacher goes through the form of teaching it, the subject is then closed, and the next in order taken up. Nothing leads up to it, and no use is made of the knowledge after the lesson is over. The seasons cannot be taught unless the experience of the whole round of the earth is the basis, and, conversely, teaching the seasons means small doses taken at intervals during the year. For this reason, a globe properly oriented and firmly fastened where the noonday sun can shine on it is an excellent device for



teaching seasons. This work must really be introductory to the use of any contrivance for illustrating seasons. By proper orientation is meant a position of the globe so that its axis is pointing in the same way as the axis of the earth; or so that the plumb line in one position of the rotation of the globe will pass through the station of the observer. When this position is assured, the globe should be set in the sun and fastened against any movement except rotation. This accomplished, it will be found that at noon on any day the sunshine and shadow on the earth and on the globe exactly correspond. A number of easy lessons should be introduced in order to make the way a relatively simple one. The observation of the changes of the day and night zone over the globe during the year, with particular emphasis at the time of the solstices and equinoxes, has a decided advantage over most methods of teaching these topics. There is always the necessity of time, during which the pupils must absorb the teaching, and in this distribution throughout the year such a period is given. The curiosity of the pupils may be awakened in this exercise as in the preceding one, but whether or not it is done in the same way, the teaching resultant will be almost negligible unless the pupils are made ready to receive the instruction.

A careless teaching of these topics in early or grammar grades is, of course, a waste of time, and later, when in physical geography courses the idea of seasons arises, the hazy notions show that the students have never really understood the principles involved. These young people are not ready for sun discs and planetariums so much as for the observation of the seasons as depicted on the globe.

Furthermore, the difficulty experienced by textbook writers in expressing in diagrams the seasons is communicated to the pupils.

The illustrations of some textbooks in this respect are stupid in that to illustrate one principle of earth position another has been violated; but as the newer texts come into the market a vast enlightenment concerning the possibilities of season diagrams seems to have been realized. Some of the diagrams which are even now in use are clear only when the subject is fully mastered; in no way are they aids to the understanding. However, a common diagram used today in books is helpful, especially in connection with the illustration of the seasons as shown during the year by the sun and an oriented globe; this diagram shows the earth in different positions around the sun, and the observer is at

an infinite distance away so that the lines of vision strike at right angles to the plane of the ecliptic. So it appears that the subject of seasons has been a stumbling block, and the solution of the difficulty probably lies in these lines of procedure: the realization of the proper time to begin the study and the proper speed for continuing it, the possibility of arousing an interest in the problems, and the necessity of presenting the subject as far as possible free from encumbering mechanisms and illusive diagrams.

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### MUSIC AND NEWS TRANSMITTED BY WIRELESS PHONE.

Public announcement of this new wireless age, marking as it does, according to the published notice, a remarkable step forward in the distribution of the world's news and music, was made recently in the form of "an invitation-to-listen," sent out by the high-powered Oscillating Audion Transmitter at the DeForest Laboratories. The notice itself was novel—first, in the sense that it was entirely "wireless," and, again, in being addressed to the several thousand amateur wireless operators within a hearing radius of New York. It foretells, according to the inventor of the Audion Lamp, "the coming of the world's first regular spoken, or wireless telephone, newspaper."

To transmit the human voice by wireless telephone, the speaker, or operator, talks into an ordinary microphone, like those used on the regular telephone apparatus in the city service. In the case of a musical selection, the microphone is placed inside the cabinet of a Columbia graphophone, where it will get the full volume of sound, and when the Columbia record is made to play, the musical notes, like the vibrations of the human voice, are taken by wire to a coil where they are transformed into high frequency waves of high voltage. Thus they are sent out, by the Oscillating Audion, for public enjoyment. At the receiving end, the music or spoken word is heard by means of the regular wireless ear pieces, which are like those used by the girl operators at the public telephone stations.

"It was hardly more than a year ago," remarked Dr. DeForest, the other day, "when the public heard of the Arlington Station wireless telephone test, which recorded, by means of the Audion Lamp, the transmission of the human voice from Washington, D. C., to Honolulu, without the use of wires. Experimental work on such a scale is highly interesting from the point of view of a wireless stunt. It is only the practical application of this work, however, that directly concerns the public, and the possibilities in the direction are clearly shown, we believe, in the wireless concerts we are now sending out at our laboratories. Personally, I can see no reason why the wireless telephone transmission of news in the near future will not be a regular means of communication, and a very valuable one, too, in supplementing by bulletin the various editions issued by the metropolitan newspapers. All that is needed is the news, and a comparatively few well-located high-power stations capable of covering the entire country. Already we have in the United States, I should say, at least 200,000 amateur wireless outfits, waiting to receive news and music by the wireless telephone."

**DULANY CAVE.**

BY H. K. RHODES,

*High School, Chambersburg, Pa.*

Locally, Dulany Cave has a fair amount of fame; yet its fame has not "gone abroad in the land" as has that of Luray Caverns and similar grottoes. Although its size and calcareous formations are not to be compared with Luray, it is more than a cave, and on account of its many ramifications might well be called the more dignified name of caverns. I do not know of any attempt to make a thorough and complete exploration; considering the number of interesting facts connected with it, I think the cave would bear further investigation.

The region in which the cave is situated contains many interesting things for the geologist and for the lover of nature. The relief, the coal measures, the peculiar formations of rocks, the fossiliferous limestone, the rivers—all make this section of the state of Pennsylvania worth a visit.

Dulany Cave is located in Fayette County, in the Uniontown quadrangle, seven miles south of Uniontown and three miles southeast of the village of Fairchance. It is easy of access, the trolley running from Uniontown to Fairchance every hour. From the latter, a private or secondary road runs up into the mountains towards the cavern, but does not lead to it; so that a trail has to be followed for about a mile. Fairchance has an elevation of 1,055 feet; the caverns, 2,640 feet. The end of the trail brings us to a little plateau from which an excellent view can be had toward the west and northwest. From this point, there is another rise to 2,714 feet. The rocks on the surface of the plateau are mainly blue, sandy limestone, or sandstone grading downward into calcareous limestone, and usually containing sandy shale.

On the western edge of this plateau are the two entrances to the cave, the larger being about the size of a coal mine entrance. Progress from the mouth is continually and gradually downward. From all appearances, the roof is not far from the surface and continues thus for some distance. From the entrance and throughout the main cavern, there is an indentation or groove about two inches deep in the centre of the roof. On both walls from the floor up to about three feet, long shallow grooves, one-fourth inch deep, run parallel two inches apart; this is especially noticeable through the main cavern. Also,

near the mouth, a stream of clear, cold water rises from the floor and runs through the main cavern.

Evidently, this stream is the remnant of a larger surface stream. The rock being of a shaly nature, the vertical and the lateral erosion may have been fairly rapid and a deep channel soon cut. Reaching out on each side, the stream encountered softer rock; the walls of the channel collapsed, forming a tunnel-like structure with a fissure through its roof. The sediment constantly washed down may have formed an obstruction which retarded the water. The stream then flowed at a certain level indefinitely, thus causing a groove in the walls. After a time the obstruction broke, the water fell to another level, another obstruction was made, and another groove cut in. This process continued until the stream was diminished, due to its source diminishing.

The main cavern has been explored for two and a half miles. There are several rooms, large and small. The first one is about three hundred feet from the entrance, and is large enough to encompass a house. In this room and in other parts, stalagmites and stalactites have been found, some a foot in length.

The number of bats which hibernate here is great. They have been observed hanging from the roof in circular masses, six feet in diameter. Three species have been captured: *Myotis subulatus*—the little brown bat, *Vespertilio fuscus*—the big brown bat, and *Lasiurus borealis*—sometimes called the white bat, the hairs being tipped with white.

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#### THE FREEZING POINT OF MERCURY.

The Bureau of Standards has just completed a very careful determination of the freezing point of mercury, using platinum resistance thermometers to measure the temperature. The result of this work gives  $-38.87^{\circ}\text{C}$ . ( $-37.97^{\circ}\text{F}$ .) for this temperature.

It is interesting to note that as far back as 1862 the English Government, recognizing the importance of an accurate knowledge of this point appropriated £150 to have it determined. The value then obtained,  $-38.85^{\circ}\text{C}$ . ( $-37.93^{\circ}\text{F}$ .), is in good agreement with that obtained at this Bureau. However, other determinations, made previous to and after this early work, cast some doubt as to its accuracy. It can be seen that knowledge of the freezing point of mercury is of great importance to thermometer makers, as it marks the lower limit to which a mercurial thermometer may be used, and furnishes a method for calibrating or pointing the scale below  $0^{\circ}\text{C}$ . ( $32^{\circ}\text{F}$ .).

## SHUNT GENERATOR.

BY E. C. MAYER,  
*Cornell University, Ithaca, N. Y.*

## PART I.—INTRODUCTORY.

Faraday discovered that when any portion of a complete circuit is moved through a magnetic field in such a way that the total number of lines of force threading the circuit is increased or diminished, an electric current circulates in all parts of it.

This may be viewed as follows:

**INDUCED CURRENTS:** Let there be a conductor, shown in cross section in Figure 1, which forms part of a complete circuit.

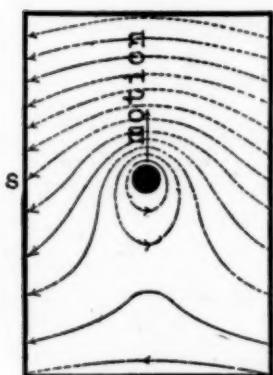


Fig. 1

Suppose it to be moving in the direction of the arrow in a magnetic field originally uniform. The arrangement of the lines of force of this field is indicated by the dotted lines. During the motion of this conductor, the otherwise uniform field will be distorted. The field of force on the side *towards* which the conductor is moving will be stronger than before, and the lines of force will be crowded together, and concave towards the conductor. On the opposite side, the lines of force will be more widely separated, and convex towards the conductor. Immediately around the

conductor, and extending to a greater or less distance, according to the intensity of the induced current, the lines of force will be closed curves surrounding it. The positive direction of the lines of force in these closed curves are as indicated in the figure. It follows that if the direction of the lines of force is to the left, the current will be directed towards the observer.<sup>1</sup>

**INDUCED E. M. F.'s:** Since a current may be produced in this way, it must be that there is an E. M. F. generated in the moving conductor. This E. M. F. exists whether the circuit is closed or not. In the latter case, if the motion is uniform, and in a uniform field, there will simply be a static fall of potential along the conductor in the direction in which current would flow if the circuit were completed.

<sup>1</sup>A rule, known as Fleming's right-hand rule, to give the direction of the induced E. M. F. or current, when the directions of motion and external magnetic field are given, is as follows: Extend the thumb and first two fingers of the right hand so that they are mutually perpendicular. If the thumb is pointed in the direction of the motion, and the first finger in the direction of the field, the second or middle finger will indicate the direction of the induced E. M. F. or current.



**A SCHEMATIC GENERATOR:** In Figure 2, a coil, ABCD, is revolving in the field between the poles N. S. of a magnet. The ends of the coil are connected with the insulated metal rings E and F on the shaft  $OO'$ . Metal "brushes" rest or slide on these collector or "slip" rings. By means of these brushes, the current induced in the coil ABCD flows through the external circuit. Such a machine forms a simple alternating current generator. By winding the coil on an iron cylinder, the intensity of the magnetic field is increased, and thus a greater E. M. F. is induced.

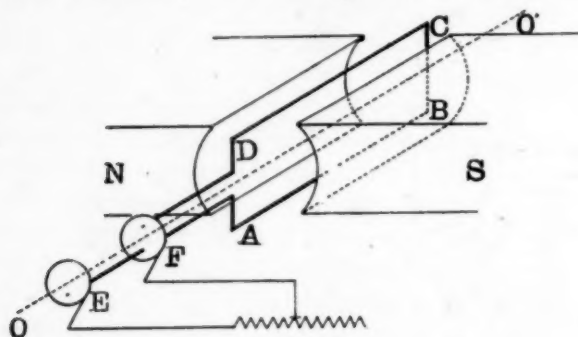


FIGURE 2.

**THE COMMUTATOR:** To obtain a uni-directional current in the external circuit, a commutator is used instead of collector rings. Figure 3 represents a two-segment commutator. This consists of a metal ring, which has been cut into two half rings. These half rings are insulated from each other and form the ends of the coil ABCD. The brushes E and F are  $180^\circ$  apart, so that one rests on one-half of the commutator, while the other rests on the other half. The brushes make connections for the current with the external circuit. The brushes are adjusted so that the

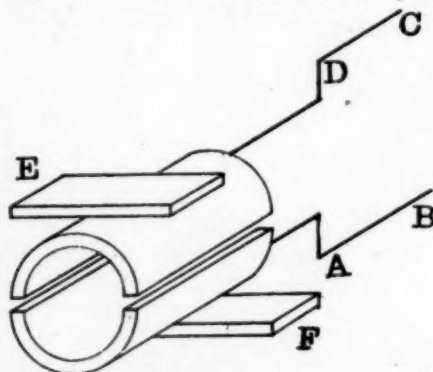


Fig. 3



connections with the external circuit are reversed, at the instant approximately when the coil passes through the plane perpendicular to the field, that is, the instant in which the current in the rotating coil is reversed. The current in the external circuit is thus constant in direction.

**ESSENTIAL PARTS OF A GENERATOR:** The essential parts of a direct current generator are (1) the field magnets for producing the magnetic field, (2) the armature, or the coils in which the currents are induced. The armature coils are provided with a commutator and brushes in order to make connection with the external circuit. The field magnets are bi-polar as in Figure 2 or multi-polar.

**THE FIELD MAGNETS:** The field magnets may be excited by means of one of the four following methods—(a) separately excited, whereby the current in the field coils comes from a separate generator; (b) "series wound," whereby the field coils are in series with the armature and the external circuit, so that the total armature current passes through the field coils as well as the external circuit; (c) "shunt wound," whereby the field coils and the external circuit are in parallel, so that only a part of the armature current passes through the field coils; (d) "compound wound," whereby part of the field coils are series and part shunt windings.

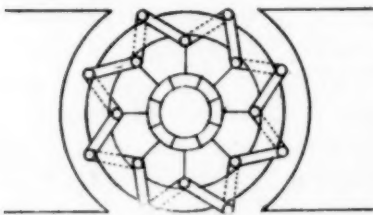


FIGURE 4.

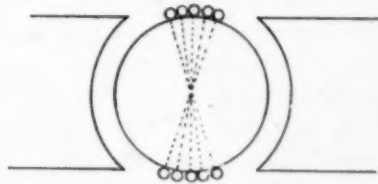


FIGURE 5.

**THE ARMATURE:** Two forms of direct current armatures are (a) the *ring armature*, and (b) the *drum armature*. The ring armature is represented in Figure 4. The coils are wound around a closed anchor ring of soft iron, and connected to the commutator segments as indicated. Only the outside wires of the ring are inductors, as the wires on the inside are shielded magnetically by the iron ring.

The simplest form of drum armature is shown in cross section in Figure 5. It consists of a cylindrical core of soft iron upon the surface of which and parallel to the axis are the conductor windings. The return conductor for any particular conductor is usual-

ly placed diametrically opposite to the latter in a two-pole generator. The chief difference between a ring and a drum winding lies in the fact that in the drum winding all the conductors on the surface of the cylindrical core cut the flux emanating from the poles, whereas in the ring winding only the outside conductors perform this function. The iron core increases the intensity of the magnetic flux through the coil.

The fundamental equation of the generator may be written as follows:

$$E = \frac{\Phi N p Z}{10^8} \quad (1)$$

where  $E$  is the average voltage generated by the armature,

$\Phi$  is flux or total number of lines of force emanating from one pole,

$N$  is R. P. S. (revolutions per second),

$p$  is number of poles, and

$Z$  is total number of conductors in series between the two brushes.

Equation (1) may be derived as follows:

The general conditions under which electromagnetic induction occurs may be stated in two ways: (a) An induced E. M. F. is developed in a circuit whenever there is a change in the number of lines of force passing through the circuit, whatever may be the cause of the change; and the magnitude of the E. M. F. is proportional to the rate at which the change occurs. (b) When a conductor is moved so as to cut across the lines of force of a magnetic field, or when the magnetic field moves so that the lines of force cut across the conductor, an induced E. M. F. is produced whose magnitude is proportional to the rate at which lines are cut. The two statements are equivalent.

A single conductor will make one complete revolution in  $1/N$  sec.; the time required for it to pass one of the pole faces, that is, the time required for it to cut the flux  $\Phi$  or total number of lines of force emanating from one pole, is  $1/Np$  sec.

By means of statement (b) above,

$$\text{Induced E. M. F.} = \frac{\text{total number of lines of force cut}}{\text{time required for cutting}}.$$

$$\therefore e \text{ (c. g. s. units)} = \frac{\Phi}{Np}$$

$$e \text{ (volts)} = \frac{\Phi}{\frac{1}{Np} \times 10^8}$$

If  $Z$  armature conductors are in series between the two brushes, the E. M. F.'s induced in the individual conductors will add, and the total E. M. F. induced will be equal to

$$E \text{ (volts)} = \frac{\Phi Z}{\frac{1}{Np} \times 10^8} = \frac{\Phi N p Z}{10^8}$$

The student is advised to become familiar with the component parts of machine assigned and to look over their construction and relation to one another, in order to get a general idea of the generator. The following data table is then to be completely filled out:

GENERAL: Type of generator.....shunt or compound.  
 Rated voltage .....  
 K. W. output.....  
 Speed .....  
 Armature: Type .....ring or drum.  
 Kind of brushes.....  
 Fields: Number of main poles: bi-polar or multi-polar.

#### PART II.—MAGNETIZATION CURVE.<sup>2</sup>

##### A. Data.

The machine is connected as a self-excited shunt generator, Figure 6, and is driven by means of a prime mover (generally a

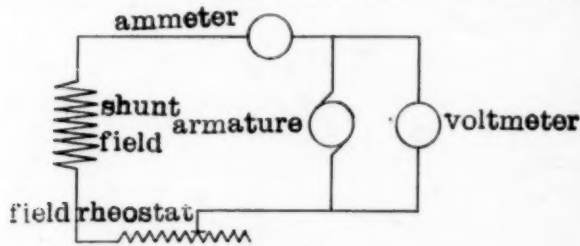


FIGURE 6.

belted motor) without load at constant speed. Readings are taken of field current  $I_F$ , terminal voltage  $E$ , and speed.<sup>3</sup> The

<sup>2</sup>Also called excitation characteristic, internal shunt characteristic, no-load characteristic, or no-load saturation curve.

<sup>3</sup>Speed is conveniently determined by means of a Starrett speed indicator, No. 104 or 106, the spindle of which is placed in connection with the revolving armature shaft.

field current is varied by adjusting the field rheostat by about ten steps from its position of maximum to minimum resistance. This gives the ascending curve; the resistance is then increased again by about ten steps to its maximum for the descending curve.

*B. Curve.*

Voltage readings are corrected by direct proportion for any variation in speed. If the speed varied during the run, the values of voltage as read are to be corrected to the values they would be at some assumed constant speed. Since for any given field current, voltage varies directly with speed, this correction is simply made by direct proportion; each voltmeter reading is multiplied by the assumed speed and divided by the observed speed. For example, if assumed constant speed be 1000 R. P. M., and voltage read be 100 volts at 910 R. P. M., the corrected voltage =  $100 \times \frac{1000}{910} = 110$  volts. The magnetization curve may then be plotted between generated volts as ordinates and field amperes as abscissas. The curve showing this relation is shown in Figure

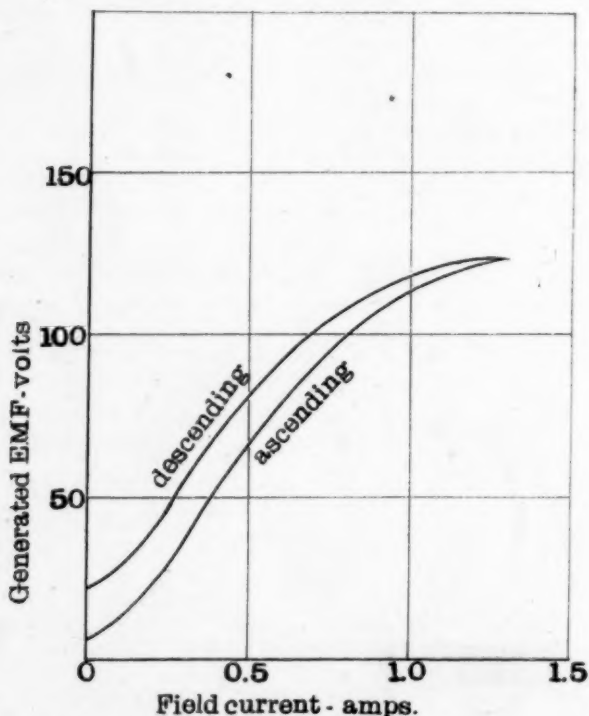


FIGURE 7.

7. In the case of a generator, in interpreting the magnetization curve, use may be made of the fact that field amperes are directly proportional to the magnetizing force or the magnetic field, and generated voltage will be a measure of flux, all other quantities being constant.

### C. Questions.

1. Interpret the magnetization curve.
2. Explain why the ascending and descending curves are not coincident.
3. State the purpose which residual magnetism serves.

(Continued in March.)

### CLASSROOM SAYINGS.

The pelvis girdle consists of the 2 hips and the sternum. We sat on the bottom of each hip. If we did not have any hips we would be balancing on the end of the spinal column and this would not do.

The oviduct of a frog secretes a digestive fluid.

Bilateral symmetry is cutting an earthworm which is in an upright position exactly in the center of its body from its head to its tail and these two parts form two new adults.

The second stage in the development of a jellyfish is an embryated cilio (ciliated embryo).

Flies go round on dirty garbage piles ect, and then come into the house and crawl all over our vitals that are on the table ready to eat.

Flies walk on dirty places and get germs on themselves. They walk on food. we swallow the germs giving us the decease. Thus we know the fly is a decease carrier.

The crayfish molts by eggs.

The starfish reproduces by the regeneration of lost parts.

Yellow fever is prevented by spilling kerosene into water.

The following, repeated *verbatim et literatim*, was the answer to a question in biology:

"Two characteristics of nitrogen are the plants take in nitrogen that we breath. thus it builds up plants. The nitrogen allso helps to keep the presure of the air uniform, if there were no nitrogen the presure of the air would be so great there would be no people on the streets A compound that forms as a wast product in the body is fats and oils. The body get rid of this waste by means of little animals called ezema. which ground the food into little bits. The food goes through the neck into the large intesting, then into the small intesting, then it passes through some more part of the body and out the blood tubes making heat."

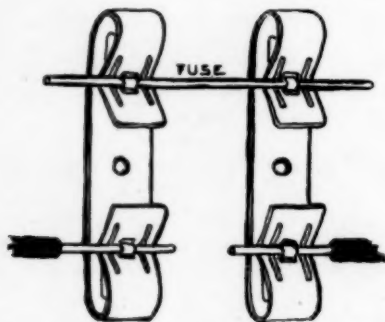
**ANOTHER FUSE DEVICE.**

By H. L. CHASE, A. M.

*Stevens High School, Claremont, N. H.*

Many electrical instruments are not safe in the hands of certain members of any physics class. They are liable to be ruined by overloading. This is unfortunate, for such instruments are often of a nature that demands personal contact and investigation for complete understanding. Nor is it policy to allow certain of the class to use the instruments while others look on. And even the "pride of the class" may blunder.

Use of a fuse in the line should be enforced. It should become the natural thing to do. In my own work, this has added one thing more to explain, and something to be wondered over at a time when attention should be sharply focused on experimental observation.



Both the fuse plug and the cartridge fuse offer problems, and in a large class an appreciable expense. Moreover, they are not fundamental. That both should be understood at some time is of course granted, but the fuse wire is the essential in both of them, and in neither is it plainly visible.

By using two double Fahnestock pattern connectors on a block of wood 3"x4", a simple fuse block is made. They are arranged parallel, an inch apart. Between two of their ends a fuse wire of the proper capacity is used. The other two ends are for the line. This is very understandable in operation, we find. It visibly teaches a lesson in case of wrong connections, and makes any instrument safe. It prepares clearly the way for the fuse plug and cartridge fuse study. Incidentally, it gives an apparatus for the study of the carrying capacity of wires up to No. 10.

Note.—In order to make the device still more effective, a piece of insulating material should be fastened to the block between the ends of the plugs.—Editor.



**THE CYCLE OF CARBON.**

By JOSEPH C. BLUCHER,  
*High School, Kenosha, Wis.*

Nowhere can we get a better idea of the role of chemistry in life processes than by studying the so-called "Carbon Cycle." Carbon is found so universally in all plant and animal tissues, as well as in the thousands of animal and vegetable products, that the study of such materials constitutes a separate branch of chemistry, namely, organic chemistry. Therefore, carbon being a constituent element of all organic compounds, it is to a study of the "Carbon Cycle," rather than to a study of the "Oxygen" or "Nitrogen Cycle," that we naturally turn to gain a little insight into the chemical nature of life processes.

To begin with, we shall assume that our earth in the beginning of its formative period was a tumultuous, hissing mass of vapors, which later condensed into the materials of the earth somewhat as they exist today. And so conditions became favorable for the development of life. We shall not enter into a discussion as to the nature of the first life, but let us rather jump over a period of thousands of years to a time slightly antecedent to the present. At that time, we find highly organized animals treading the earth, and a rank and luxuriant growth of vegetation covering it. It is to the death and carbonization of this rank growth of plants that modern geologists attribute the formation of coal. We all know that coal, with the exception of some volatile matter and a small amount of mineral matter, is practically all composed of the elementary substance, "carbon." Here, then, we have a very convenient starting point to study the "Carbon Cycle."

We all know that carbon unites with the oxygen of the air to form a compound gas known as carbon dioxide. We also know that there is a quantity of this gas in the atmosphere. Of course, the sources of it are many; it comes from the decay of animal and vegetable matter, from combustion of organic matter, and in other ways. But let us confine our attention to a small, limited system.

To begin with then, suppose we cause coal to undergo combustion. Of course, we know that heat is liberated, and we shall see later that this is merely liberating the heat of the sun stored up ages of time before. And we also know that the products formed by the burning of the coal and its volatile matter are carbon dioxide and water. Thus we have obtained a supply of

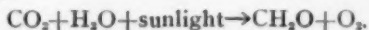
carbon dioxide in the atmosphere. But before we follow the larger cycle, or course, of carbon, from coal back to coal again, which as we shall see actually takes place in very long periods of time, let us follow its course in more limited periods of time, in much smaller cycles, which on an average may not be greater than a year in length. We mean its course from carbon dioxide of the atmosphere back again to carbon dioxide of the atmosphere; after passing through probably thousands and even millions of which small cycles, the carbon ultimately returns again to its original form—viz., coal.

The only materials necessary for our simple little study are a living plant, a living animal, carbon dioxide, and water. That the first life of our globe was probably plant life, and that in the universal process of evolution animal life was evolved from it, need not concern us here, it is foreign to the subject of chemistry. We have our four necessary things, and that is all we care about.

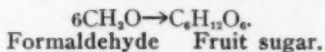
It seems that the only food materials a plant needs, besides a small amount of mineral water, are carbon dioxide and water. These two substances the majority of plants have in abundance, especially the carbon dioxide; where water is lacking, of course vegetation does not exist. It can be shown by experiment that when we supply a plant with carbon dioxide, water and sunlight, it increases in weight, *i. e.*, it grows, and gives off oxygen. This is easily shown. Since the plant gives off oxygen, the only source of such oxygen is the carbon dioxide or water. We all know that both these substances are formed from their elements with the evolution of considerable heat. And it seems to be a general rule in chemistry, or rather a law, that where a compound is formed with the evolution of energy, that energy must be applied to it if we wish to reverse the process and decompose it. So the plant, in decomposing its food materials, must have energy in some form. This is supplied by the sunlight. In some way or other, which nobody can explain, the green coloring matter of the plant, known as chlorophyll, utilizes the solar energy to bring about the chemical transformation of carbon dioxide and water into plant substance and oxygen. We know that by this action we have formed plant fibre, which is called cellulose when freed from the rest of the plant material (as in filter paper), various sugars, starches and other products, as well as free oxygen. Can we not see here another example of catalytic action, and the catalyzer to be this substance, chlorophyll? It will be well to remember

this when later on we come to study a class of substances known as ferments or enzymes.

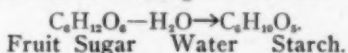
But to return to our subject, what is the chemistry involved in the process? One of the simplest equations we can write for it is the following:



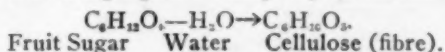
The substance represented by  $\text{CH}_2\text{O}$  is formaldehyde, so that possibly formaldehyde is initially formed and oxygen given off. This seems very probable when we consider, for reasons which could not be given here, that formaldehyde is really a sugar. This also seems like a wide stretch of the imagination when we compare formaldehyde with ordinary granulated sugar, but it is a fact that from a chemical standpoint they are put in the same class of compounds. The formula for fruit sugar is  $\text{C}_6\text{H}_{12}\text{O}_6$ . We readily see that we can obtain this formula on paper by taking the molecular weight of formaldehyde six times, thus:



In reality, the plant condenses into one molecule of fruit sugar six molecules of the formaldehyde originally formed. How this condensation is brought about we are at a loss to say, but probably by some catalytic agent in the form of an enzyme or ferment. Thus we have sugar formed in the plant, which sugar may be found in the sap, as in the sugar cane and sugar maple, or in the fruit, as in the date, the apple, the ear of corn, the head of wheat, or in the root, as in the potato. And when the ear of corn, the head of wheat or potato ripens, some other catalytic agent or ferment converts the sugar into starch, thus:



The fibre of the plant, cellulose, is made from the sugar already formed. The following equation may represent this reaction:



But what is the substance of all this discussion? Well, we now have our carbon compounded in vegetable matter, either in the plant structure, or in foods made by the plant. We can readily see that the action of the plant is synthetic in nature, forming as it does such complex compounds as sugars and starches from such simple substances as carbon dioxide and water.

Animals are divided into three classes—carnivorous animals, or those which eat flesh; herbivorous animals, or those which eat

vegetable matter; and omnivorous animals, or those which eat both animal and vegetable matter. But although carnivorous and omnivorous animals eat other animals as food, yet in the majority of cases these other animals are herbivorous, and their bodies are built up from vegetable material. Hence we can readily see that the ultimate food of all animals is vegetable matter. Such being the case, we are ready to follow our carbon on another stage of its round trip journey from carbon dioxide to carbon dioxide. We have taken away from it the oxygen with which it was combined in the carbon dioxide, and to do so required energy (sunlight).

Now, why do animals eat food? Well, one reason is that they may grow in mass. Another reason is that they require food as fuel for their organisms, for in general animals do considerable bodily work. Of course, the fuel is the carbon contained in the plants which they eat, and in plant products such as sugars and starches. Just as heat energy was given out in the original formation of our carbon dioxide from coal, and just as an equivalent amount of light energy was absorbed in decomposing our carbon dioxide in the plant, so now the animal can obtain the same equivalent amount of heat energy given out if it can bring about a combination of the carbon of its food materials with the abundant oxygen of the air. Well, the animal can actually do this very thing.

The process is simple. We shall assume a highly organized animal, for instance, man. Man is fitted with a digestive apparatus, a circulatory apparatus, and a breathing or respiratory apparatus. Digestion breaks the food materials (containing carbon) up into simpler compounds which can be absorbed into the blood. The blood stream picks up and carries the nutritious products of digestion to the parts of the body. Air is drawn into the lungs, which are lined with blood vessels. The oxygen diffuses through the thin walls into the blood and is likewise carried by the red blood corpuscles to the various parts of the body. The carbon of the food unites with the oxygen, heat is evolved, and the body temperature is sustained. The carbon dioxide resulting from combustion is carried back to the lungs in the veins, causing the blood in such to appear dark. It diffuses through the walls of the blood vessels into the lungs and is breathed out into the air. Presto! our carbon has completed its little journey full of adventures and is returned once more to its abode, the atmosphere, ready to be taken up by some other plant.

But this small cycle has marked only one little episode in the great cycle of carbon from coal back to coal. After thousands and probably millions upon millions of such lesser cycles, it finds itself again in the form of coal, having been so unfortunate as to get locked up in some plant structure which died and did not decay but was converted into coal.

So, then, if we go back to periods of time before the formation of plants or animals, we can outline the history of a little atom of carbon thusly:

- |   |  |
|---|--|
| 1. $C + O_2 \rightarrow CO_2$ .                                   | } Period before the formation of Coal. |
| 2. Plant life appears.  |  |
| 3. $CO_2 + H_2O + \text{chlorophyll} \rightarrow CH_2O + O_2$ .   |  |
| 4. $6CH_2O \rightarrow C_6H_{12}O_6$ .                            |  |
| 5. $C_6H_{12}O_6 - H_2O \rightarrow C_6H_{10}O_5$ (fibre).        | } The Cycle from Coal back to Coal.    |
| 6. Plants die $\rightarrow$ Coal + Water.                         |  |
| $C_6H_{10}O_5 \rightarrow 6C + 5H_2O$ .                           |  |
| 7. $C + O_2 \rightarrow CO_2$ .                                   |  |
| (coal) (air) (carbon dioxide).                                    |  |
| 8. $CO_2 + H_2O + \text{sunlight} \rightarrow CH_2O$ .            |  |
| 9. $6CH_2O \rightarrow C_6H_{12}O_6$ .                            |  |
| 10. Sugar eaten by animals and carbon burned.                     |  |
| $C_6H_{12}O_6 + 12O \rightarrow 6CO_2 + 6H_2O$ .                  |  |
| 11. $CO_2 + H_2O + \text{sunlight} \rightarrow CH_2O$ .           |  |
| 12. $6CH_2O \rightarrow C_6H_{12}O_6$ .                           |  |
| 13. $C_6H_{12}O_6 - H_2O \rightarrow C_6H_{10}O_5$ (plant fibre). |  |
| 14. $C_6H_{10}O_5 \rightarrow 6C + 5H_2O$ .                       |  |
| (Plants die) (Coal).  |  |

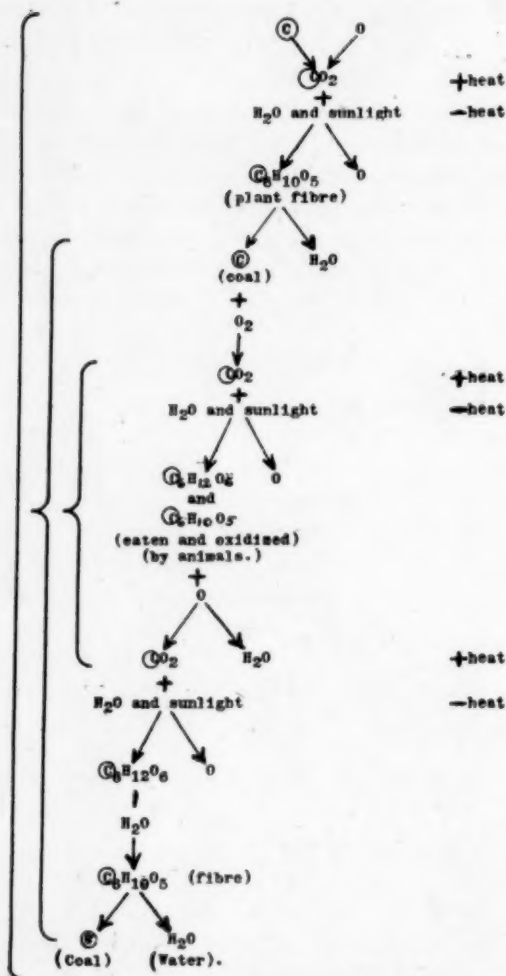
However, the history is probably better illustrated by the chart on the following page, where the carbon atom whose history we are following is printed in the circles.

In reality, the history of every atom of carbon existing today is only beginning, and will never cease until the earth becomes so cold that life and all chemical processes must cease.

Now, in concluding our study of the "Carbon Cycle," let us see what things we have learned.

1. That whereas all the carbon originally existed on the earth in the elementary state, and later in combination with oxygen, now through the agency of plants, much of it has been converted into free carbon again (coal).

2. That this process is continuing and will continue as long as plants exist, and that ultimately all the carbon will be in the form of coal if the supply of atmospheric oxygen does not last, or in the form of carbonates if the supply of oxygen continues; that is, the carbon of the present day coal may some time be converted into carbon dioxide and subsequently into carbonates.



3. We have also learned a little of the history of coal, the growth of plants and elaboration of plant products, and a little about the animal body.

4. And we have casually noticed the energy cycle involved.

5. After studying this carbon cycle, we can easily understand the oxygen cycle in life processes.



## CHEMISTRY AND EFFICIENCY.

By P. M. GLASOE,

*St. Olaf College.*

In proportion as the word and idea of "efficiency" have become household possessions, so to speak, in educational circles, they are defeating their own aims. We are doing this generation small favor in teaching them to understand that efficiency is all-important and all-sufficient. Even though broad-gauged educators do not mean it to be so construed, that is the idea that will stick in the shallow mind of the average patron of our educational system. It has been a pleasure to note the recent appeals for a saner foundation for education than mere superficial efficiency.

Take the subject of chemistry for example. People with more zeal than understanding of the subject have insisted on making it practical from the very start; that is, even high school chemistry must be taught so that the boy and girl may go out into life with practical ideas for future use. It is unnecessary to say that the teacher who follows out the suggestion and dabbles in a course of elementary technology can not lay a thoroughly scientific foundation for the subject. The laboratory work becomes a blind following out of prescriptions with no adequate conception of the reasons underlying. The practical results which such a pupil takes with him into life will consist of a series of rule-of-thumb processes without the scientific foundations necessary for reasoning out causes, interrelations and consequences. If his memory slips up on him as to whether oxalic acid or soda was to be used, whether he is to use caustic potash or concentrated sulphuric acid, in testing the presence or absence of wool in a piece of cloth, he is without recourse—he hasn't the scientific foundations necessary for independent deductions.

The practical year of high school chemistry defeats its own aim:

*First*, in that it does not prepare for life—inasmuch as the learning of a few chemical names or the parrot-like repetition of a few prescriptions is not practical chemistry. Much more would the end sought be gained if the year were spent in laying the necessary stress on a thorough knowledge of the foundation principles, with only now and then an incidental reference to the practical application of the subject.

The foundation should consist in a thorough understanding of and drill in the following subjects—chemical and physical change; atomic and molecular weights as a foundation for stoichiometrical problems; the laws of definite and multiple proportions; the gas laws, especially Boyle's and Charles'; acids, bases and salts; oxidation and reduction; valence with a most thorough drill in writing structural formulas with a view to representing intelligently by equations what takes place in a reaction. A discussion of the modern theory of solutions and osmotic pressure, ionization and electrolysis is both important and interesting. With this as a skeleton, a sound and scientific year of chemistry can be built. It is not enough to go over these different subjects once, they must be repeated and reiterated until they become second nature, if they are going to bear fruit in scientific thought and reasoning. Every one of these fundamentals should be impressed by stoichiometrical problems. A student who cannot solve such problems in demonstration of the principles involved has not mastered the subject matter.

A student who has gone through such a course under skillful guidance is by no means as yet a chemist, but he is an intelligent tyro who can go out into life and understand the meaning of simple, everyday, chemical terms that confront him. Should he wish to know the reason for a set of facts that he does not understand, he has enough foundation so that he can read intelligently a not too technical discussion on the subject.

The difference between the products of the two systems of training is this: Anyone may keep his finger on a prescription and pour when it says to pour and filter when it says filter, but it takes real fundamental chemical knowledge to know why you pour, what you get when you add a precipitant, and why you filter.

*In the second place*, such a course does not prepare for future study. Too many teachers of college and university freshmen have had sad experience with these practically trained chemists. College teachers have been heard to say that they wish chemistry were not offered as a college prerequisite; students would then, at any rate, enter the freshman class free from predilections on the subject. As it is, they are utterly unfit for the sophomore course in qualitative analysis; they resent being compelled to take the freshman work together with others who have not had chemistry before; therefore, they either do not take it up or they are at a decided handicap in the prejudice which rankles in their

breasts if the subject is compulsory. They do not understand their own dilemma. They do not know wherein their deficiency lies nor that they have one. They know a few names, can ask for the  $H_2O$  and the  $NaCl$  at table, and consequently do not need to spend two hours a day in preparation for the recitation. Before they realize it, the foundation discussions are passed and they are floundering about, aimlessly snatching at a name here, a formula there, that happens to have a familiar sound, but the real essence of the subject, the foundation upon which to build advanced study, has eluded them.

My contention is simply this: In an attempt to make chemistry intensely practical, we destroy the very properties for which it has been cultivated as an educational subject. It degenerates into empiricism and is not scientific. Like alchemy of old, it desires to touch nature's raw materials with the philosopher's stone and convert them into useful and practical goods—it becomes a course in imitation, not in independence of thought and action. It trains the pupil to be dependent and helpless instead of making him able to rely on his own knowledge and judgment.

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#### POTASH IN LAKE MUDS OF WESTERN UTAH.

Potash in surprisingly large proportions is present in the brines and muds of the Salduro Marsh, a sink in the Salt Lake Desert, about sixty miles west of the southwest edge of Great Salt Lake. From the clays underlying the salt body which covers the marsh, the U. S. Geological Survey collected samples at depths of eight to twelve feet, in which the dissolved salts were found to contain from two to about  $3\frac{1}{2}$  per cent of potash, and  $2\frac{1}{4}$  per cent was found in the soluble salts at a depth of about four feet. Of the dissolved salts contained in the brines occupying the spaces between the salt crystals in the crust overlying these muds, three to four per cent was found to be potash.

Singularly enough, the salt crust left at the surface of the desert through the evaporation of the brines contains little more than a trace of potash, most of the potash being confined to the brines and to the muds underlying the salt crust. The successful extraction of this potash is a fascinating as well as most pressing problem for the chemical engineer. According to analyses made by the Survey, the brines and muds from the Salduro Marsh contain considerable magnesium chloride, as well as chlorides of potassium and sodium, and so are somewhat similar in composition to the deposits from which potash is manufactured in Germany. Therefore, it appears that success in methods for manufacturing potash at the Salduro Marsh should prove comparatively easy. While no extensive exploratory work has been done by the Survey to show the area of the deposit, it is believed that the amount of potash present in the region, if it can be extracted with commercial success, is sufficient to provide a valuable source of supply to the country.

SHORT STORIES OF GREAT INVENTIONS.<sup>1</sup>

BY A. L. JORDAN,

*Polytechnic High School, San Francisco, Cal.**(Continued from January.)*

6. **THE STEAM TURBINE** is coming to be the modern colossus of power, and for large units, especially in direct connection to dynamos, is replacing the reciprocating engines. We now read of the construction of turbines of 40,000 horsepower!

The reaction turbine of Hero has been mentioned, as has the impulse or steam-jet type of Branca, but it was not until 1883 that the Swedish engineer De Laval brought out his remarkable impulse turbine with its curved buckets and high speed, giving great power in small space. Parsons, in England, was close on his heels (1884) with a multiple nozzle turbine of similar type. This was improved in various ways, and finally found a worthy rival in the combined impulse and reaction type of Curtis, in America, in 1896. The last two were brought out in this country by the Westinghouse and the General Electric Companies, respectively.

7. **WATER WHEELS.** A paddle wheel, turned by a jet of water, has been known since the times of antiquity; "overshot" wheels have been familiar to the Chinese for centuries; and "current wheels" ("undershot," sometimes on an anchored raft) probably revolved on streams in prehistoric times. A very early type is the "breast wheel," a compromise between the overshot and undershot.

The use of curved buckets was first proposed by Euler, the great Swiss mathematician, in 1754. Various forms of curved bucket turbines were developed, especially in France, in the next seventy years. One marked type, the "inflow turbine," was put forth by Poncelet in 1826 and developed in 1849 in this country by J. H. Francis. Another, the "outflow turbine," by Fourneyron in 1827, was brought out here by Morris in 1843. A still later type, where the flow is in, down, and out, has been named the "American." These were intended for low head.

Going back to the flat paddle wheel, we find that the early California miners, having numerous water jets at hand, used their crude "hurdy-gurdys" for sawing lumber, etc. The first suggestion for an impulse water wheel came from Professor Hesse of the University of California in 1867, and he had a small wheel built and tested then, but did not patent it. The

first patent was that of Pelton in 1880. An improvement in the shape of the bucket (ellipsoidal, with a recess in the lower part) was patented by Doble, the patents being recently acquired by the Pelton Company. The Pelton and Doble wheels, developed on the Pacific Coast, are in use in most of the high head water power plants of the world.

One other kind, the reaction wheel (original form being Hero's engine) was adapted to water power by Barker (Am.) in 1740. This wheel is rarely used now, but finds an application in the common lawn sprinkler.

8. THE HYDRAULIC RAM was invented by John Whitehurst (Eng.) in 1772. In his crude appliance, the valves were closed by hand. Joseph Montgolfier (one of the brothers who sent up the first hot-air balloon) made a practical machine of it by adding the automatic feature in 1796.

A more recent device which has been added is a small valve for sucking in the air necessary for operation. After the momentum of the moving column of water is checked, if there were no recoil, the pressure would (in many cases) not be reduced sufficiently to allow the main valve to open.

Another interesting application of the ram is its use with a large flow of impure water to pump a small amount of pure water to a considerable height.

9. WIRELESS TELEGRAPHY had its beginning when the body of a frog was seen to twitch when a frictional machine was worked near it about 1750.

The existence of a "universal ether" was suggested by Huygens in 1678; Faraday showed some experiments proving its existence in 1845; and the great English physicist Maxwell in 1864 stated the possibility of waves in this ether. Felix Savary in 1827 had observed the variations in polarity of a steel needle magnetized by the discharge from a Leyden jar. Joseph Henry (Am.) in 1842 repeated this experiment, and proved that the spark discharge is oscillatory; and Hertz (Ger.) in 1888 showed the transmission and reception of the waves set up by that discharge. (Hertz used a spark-gap detector, but the same device had been used by the Thomson and Houston in 1875 and by Edison about the same time.)

S. P. Thompson came very near to Hertz's discovery in 1876, when he noticed sparks between two door keys fastened close together on a block of wood.

Professor Branly, in France, invented an important form of



coherer in 1890; but, one year earlier, coherer action between pieces of metal had been noticed by the Englishman Lodge, who also discovered the important principle of syntonizing.

These were not the first recorded observations on coherers. Munk (1835) noted increased conductivity in tin filings, loose carbon, etc., after a Leyden jar discharge; S. A. Varley (1852) found the same thing after an atmospheric discharge; Hughes re-discovered Munk's experiment in 1878; and Calzecchi-Onesti made a similar observation in 1884.

Tesla, the Austro-American inventor, patented his high-frequency coil in 1891. Marconi, in 1899, using the Tesla coil, the oscillatory discharge, and the coherer, and adding two important features (an elevated aerial and powerful discharges), astounded the world by signaling across the Atlantic Ocean. Other experimenters in "wireless signals" were Preece, Henry, Edison, and Trowbridge, as well as Tesla.

Mention should be made of detectors other than coherers. One was the hysteresis magnetic detector (Rutherford and Marconi), another the vacuum valve detector (Fleming in 1904, De Forest later). The latter invention, however, was antedated by the work of Edison, who used a vacuum bulb as a "rectifier" in 1884. The first important type of "crystal" detector, now in such common use, was the carborundum detector of General Dunwoody (U. S. Army) in 1906. Discovery of the electrolytic detector is claimed for Fessenden (1903), Ferrie, Nernst, Vreeland, and Schlomilch, but Pupin is credited with the original use of a similar device for rectifying alternating currents in 1898.

10. THE TELEPHONE is, like the other inventions, the culmination of a series of ideas. Charles Bourseul in 1854 suggested a flexible disc "to make and break the current from a battery." In Germany, in 1860, Reis produced a singing or "musical" telephone. He died unknown and neglected, but his apparatus, though imperfect, embodied the great principle.

The next development shows one of the most extraordinary coincidences in the history of invention. Alexander Bell of Boston and Elisha Gray of Chicago, within two hours of each other, February 14, 1876, applied for caveats for a telephone instrument at the patent office. This instrument was the one now used as the receiver. Over this there was an enormous amount of litigation, Bell winning the suit, partly because of priority, partly because his specifications showed better knowledge of the subject.



The microphone transmitter was invented by Berliner in 1877; Edison followed, three months later, with a carbon transmitter of plumbago; and Hughes, Blake, and Hunning introduced other improvements. Berliner's patent was contested by Edison, Gray, Richmond, Dolbear, Holcombe, Bell, and others, but after fourteen years of litigation it was awarded to Berliner, and was later bought by the Bell Company.

The thoughtful mind is filled with wonder at being able to catch even the inflections of a friend's voice, and now the telephone engineer amazes us with his conquest of distance. You can talk from New York to San Francisco!

11. THE ELECTRIC TELEGRAPH. The beginning of telegraphy with wires was in 1673 when Otto von Guericke, working with his newly invented frictional machine, noted the distinction between conductors and insulators. Using wires to conduct electric charges was rediscovered by Stephen Gray in 1729 in England. The French physicist Ampere suggested the possibility of electromagnetic signals at the distant end of a wire in 1821, but the first actual apparatus was that of our own Joseph Henry in 1830. He used a permanent magnet and a bell, running the wires around his lecture room. The first working telegraph in Europe was that of Gauss and Weber in 1833, and in England Wheatstone and Cooke had a successful system in 1837. In the United States the idea (using the electromagnet) was patented by Morse, and the first telegraph message was sent by him in 1844.

Steinheil (Ger.) in 1837 discovered the great saving of wire by the use of the "earth return," but it is interesting to note that this was used by Franklin many years before when he sent a discharge of static electricity under the Schuylkill River.

Submarine telegraphy needed a far more sensitive instrument than the telegraph relay or sounder, and this demand was met by Lord Kelvin who brought out his mirror galvanometer about 1857. This was followed by his siphon recorder (moving coil) in 1865. The next great improvement was the "duplex" and then the "quadruplex" (the latter now used mostly for land lines) by Edison in 1872-73. Meanwhile, in England, Wheatstone completed his automatic telegraph (1868). This now allows a speed of five hundred words per minute. Later schemes of rapid or machine telegraphy, printing telegraphs, etc., have been numerous, but in spite of the telephone and even of wireless telegraphy the old "Morse" is still clicking out the great news service of the world.  
(*To be continued.*)

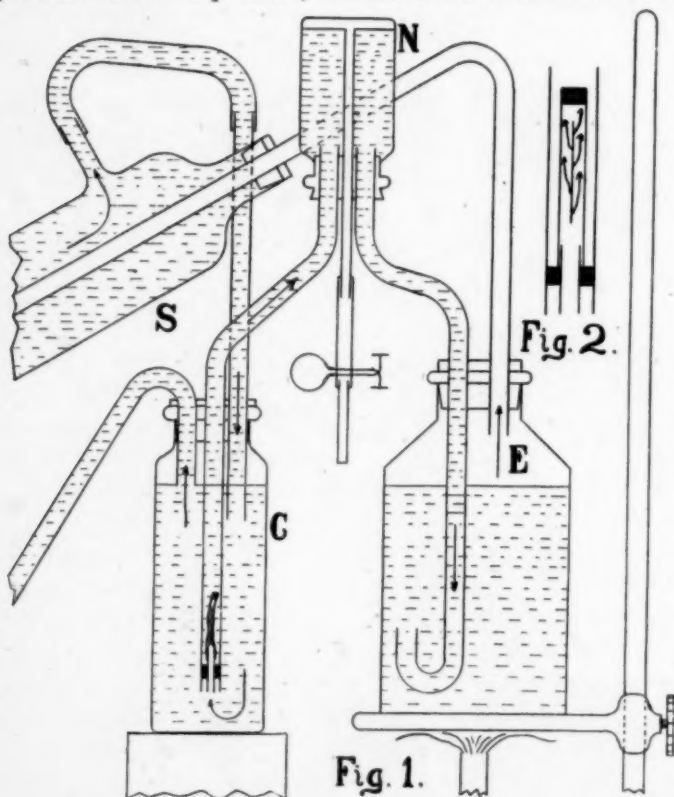
**AN AUTOMATIC STILL FOR SEVENTY CENTS.**

By H. A. WEBB,

*Department of Chemistry, West Tennessee State Normal,  
Memphis, Tenn.*

An automatic still, as a rule, is an expensive piece of apparatus, and many small laboratories do not possess one. On the other hand, distilling water in the usual manner from a retort involves constant attention lest it boil dry. Some months ago, I designed and assembled an automatic still which may be improvised out of materials to be found in the simplest laboratory.

For eight months I have used this still, arranged as in Figure 1. The boiler (E) is any old syrup, alcohol, or molasses can which has one opening. At the side of this, any old bottle (C) is placed, at a convenient height on a block. From bottle to boiler, a siphon tube runs, but at the highest point a small bottle (N) is inverted, which acts as an air trap. A small tube, running as high in this bottle as possible, connected with a small rubber tube,



allows air to be sucked out periodically (e. g., once a week). At all other times, this small tube is clamped, or tied with a knot. This arrangement prevents the siphon tube from being broken by air bubbles.

The tube entering the boiler is bent upward at the end, so that steam will not enter. The other end of the siphon has a valve (Figure 2), which prevents hot water from being pumped back from the boiler. The slit which constitutes the valve is about an inch long, and is tightly closed by back pressure. Without this arrangement, much of the hot water will be wasted, and the boiling intermittent.

The level in bottle and boiler is maintained by a siphon with one very short arm. This overflow will automatically start itself, and continue with air and water sucked over in rapid alternation. The water level in this bottle should be high enough to allow the water in the boiler to become depressed about an inch, this difference being sufficient to pull the water through the valve and siphon tubes.

The outflow of the condenser (S) pours into the leveling bottle, and the water not required in the boiler is carried out by the overflow siphon. A metal or asbestos plate may be hung between bottle and boiler as a precaution.

In the illustration, the still is connected with a Liebig condenser. As a matter of fact, however, in the effort to ascertain the minimum cost of such an arrangement, the materials were obtained as far as possible from a pile of rubbish. An itemized list of materials and cost follows:

Materials.	Cost to Me.	Approximate Value New.
Old syrup can.....	\$0.00	\$0.15
Old pickle bottle.....	.00	.03
Old olive bottle.....	.00	.02
Old two-inch iron pipe, as condenser jacket.....	.00	.10
Four rubber stoppers.....	.40	.40
Glass tubing, less than $\frac{1}{4}$ lb.....	.10	.10
Rubber tubing, two sizes, $1\frac{1}{2}$ ft. ....	.20	.20
Stands, etc., improvised .....	..	...
Total cost .....	\$ .70	..
Approximate value .....	..	\$1.00

If regular laboratory stands, clamps, and a Liebig condenser are used, the cost is increased by about \$1.75.

The capacity of the still, which I have used exclusively for the past eight months, is about one liter per hour with one Bunsen burner. It has worked without a hitch, and I frequently let it run all night. The only operations necessary to start it are turning on the water, and lighting the gas.

**WHAT DO WE MEAN BY SUPPORTING COMBUSTION?**

BY O. L. BRAUER,

*Selma, Cal.*

Many high school students have difficulty in telling whether a substance burns or supports combustion. When we look for the fundamental difference between burning and supporting combustion, it appears that generally there is no real difference, as combustion is usually defined. The common definition is: Any chemical reaction by which light and heat are evolved. Since heat is evolved in all exothermic reactions, the distinguishing feature of combustion is the evolution of light. Although the same amount of heat and the same final products may be formed under conditions favoring a slower reaction, it is not combustion unless light is evolved. A piece of sodium may be left in the air and turn to the oxide in a relatively short time, yet it is not combustion as no light appears.

If a glowing splinter is thrust into a bottle of oxygen, it bursts into flame and we say that the stick burns and the oxygen supports combustion. No doubt, we speak of the stick as burning because we see the flame or source of the light on the stick. The oxygen, then, aids the burning and is said to support combustion. Perhaps we might reverse this apparent phenomena by getting a stick of solid oxygen to burn in an atmosphere of hydrogen. Then we should have to say that the oxygen burns and hydrogen supports combustion. Why should we say that it is the hydrogen that burns, when a mixture of hydrogen and oxygen unite? It is true that a jet of hydrogen burns in the air. However, a jet of oxygen would no doubt burn equally well in an atmosphere of hydrogen. In speaking of a combustible substance, we should always name the other substance we have in mind as the supporter of combustion or the term has no meaning. If we have oxygen in mind, charcoal is readily combustible, but if chlorine, it is incombustible. In other words, the term has no general significance as we have defined combustion.

Yellow phosphorus unites with sulphur with explosive violence when they are heated together. Which burns and which supports combustion? There is no legitimate basis of choice. Phosphorus and sulphur both burn in oxygen. How could we say that either burns and the other supports combustion when they react?

We could not expect a child to learn good English if we

spoke to it only in "Pigeon English." So, likewise, the student cannot learn true science if we teach him "Pigeon Science." It seems to me there is need of a re-definition of our terms relative to combustion. I would suggest that we return to the original meaning of the term, combustion, and define it as only the combination with oxygen. We could speak of slow combustion and rapid combustion, or burning. A supporter of combustion would then be either oxygen or some substance that would supply oxygen for the reaction, as nitrous oxide or potassium nitrate.

It may be argued that there is a great similarity between the reaction of turpentine in chlorine gas and the burning of turpentine in the air. This is true enough, but there are also many differences. If we stick to the present definition of combustion, there is no real difference between a substance that burns and one that supports combustion. The latter term is meaningless. However, if we accept the limited definition as suggested, any substance that unites with oxygen may be said to be combustible, and the oxygen and any substance that furnishes oxygen may be said to support combustion. All other reactions that evolve heat and light are simply rapid exothermic chemical reactions. The vast number of oxygen reactions and the students' familiarity with them justify a special name for them. The extension of this to other reactions can only lead to confusion.

Let us call combustion only the reaction with oxygen. The combustible substance is one that reacts with oxygen, and the oxygen or substance that supplies the oxygen is the one that supports combustion.

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#### COAL MINED IN 1915.

The production of bituminous coal and anthracite in the United States in 1915 amounted to 531,619,487 short tons, valued at \$686,691,186, an increase, compared with 1914, of 18,094,010 tons, or 3.5 per cent, in quantity, and of \$5,200,543, or 0.8 per cent, in value, according to C. E. Leshner of the United States Geological Survey. Of this total output, 442,624,426 short tons, valued at \$502,037,688, were bituminous coal and lignite, and 88,995,061 tons, valued at \$184,653,498, were Pennsylvania anthracite. Pennsylvania, with an output of 157,955,137 tons of bituminous coal and 88,995,061 short tons of anthracite, ranks first among the coal-producing states. West Virginia, with a production of 77,184,069 tons; Illinois, with 58,829,576 tons; Ohio, with 22,434,691 tons; and Kentucky, with 21,361,674 tons, follow in order of production. Thirty states and the territory of Alaska contributed to the total, of which number thirteen states and Alaska had increased production, and seven-teen had decreased production, compared with 1914. To produce this coal, 734,008 men were employed for an average of 209 days.



**A BRIEF OUTLINE OF THE METHODS AND AIMS OF  
ELEMENTARY SCIENCE AS TAUGHT IN ATLANTIC  
CITY, N. J., HIGH SCHOOL.<sup>1</sup>**

BY CELIA F. HAAS.

Elementary science was introduced into Atlantic City High School in 1912 as a course for first-year home arts students in order that they might better understand some of the principles underlying the problems confronting them in their cooking and laundry, and to give them an insight into some of the causes and results common to their environment. At the same time, it was demonstrated that certain subjects of a chemical and physical nature were necessary for better understanding of physiography, and these were introduced into the physiography outline.

Under these circumstances, it has been easy to develop an elementary science course founded upon a physiographic basis, but containing the topics which to date are considered an essential part of such a course. The first-year science for the normal preparatory and scientific courses is still called physiography because as yet higher institutions do not recognize elementary science.

This year, 1915-1916, three hundred freshmen are registered in the course. One hundred sixty-three of these are commercial, fifty-two scientific, fifty-five normal preparatory, and thirty home arts.

From comparison with other schools, I feel that an explanation of our reason for remaining physiographic in our attitude is necessary. Every course offers two other sciences to these freshmen in later years. Biology is elective in commercial and scientific, and required in normal preparatory and home arts in the sophomore year. Physics is required in junior scientific, and elective in normal preparatory. Chemistry is elective in commercial and normal preparatory, and required in scientific and home arts. Consequently, less breadth is necessary in first-year work, because the pupil gets some science from another angle before he finishes.

The method of procedure has been, and we hope will continue to be, seven periods per week, three in recitation and two double periods in laboratory work and demonstration. As a rule, recitations precede laboratory work in any subject. Demonstrations are confined to those subjects impractical for individual work,

<sup>1</sup>Given before the Elementary Science Division of the New Jersey State Science Teachers Association, March 18, 1916.



because of expense, apparatus, or danger to unskilled experimenters. Laboratory work is always individual. It consists of a simple experiment demonstrating some fact, definite observations, directed by carefully prepared questions and a conclusion drawn from the pupils' observations. These experiments are written out, corrected by the teacher, and all mistakes rectified by the pupil before the work is considered complete.

There is among us some latitude in the matter of texts. Snyder's *First Year Science* is used with Salisbury's *Elementary Course in Physiography*. When the question is raised as to the choice of texts, opinions seem to differ, but only seem to, for while one prefers an elementary science text he chooses one "whose backbone is physiography," and another prefers a physiography because it contains more detail upon each subject. At present, the elementary science texts on the market are "compilations of samples of all things," and I fail to see how they can be much else if they are to be complete enough to fill all kinds of needs.

Regarding subject matter, the five teachers who are studying the problem in Atlantic City differ little. All give the metric system of linear measurement, matter, its states, physical and chemical changes, oxidation, atmosphere, the earth as a planet, its crust, the agents of change, the ocean, its tides and currents, and, briefly, heat. Some add brief lessons on acids, bases, and salts, light, sound, distribution of life, magnetism, electricity, and food.

I have made no distinction among the courses and do so now only to show how elementary science can be fitted to suit all kinds of needs. In the home arts course, elementary science departs from the physiography and correlates itself with cooking. Here we try to keep ahead of, rather than follow, the outline laid out for the first-year classes in cooking, so that before using fuels, water, and foods, they may know the composition, common properties, sources, and tests for them. Leavening agents, soap, soap-making, and house mechanics complete the first term's work, leaving the second half for study of our environment as the friends of elementary science understand the term.

It is evident that Atlantic City High School is peculiar in offering so many branches of science to its pupils and, because of that peculiarity, our needs in first-year science are not those of the school that must try to give in one year something of all that we may give in two. Every good teacher will teach all of the topics included in "a study of our environment," be the subject

called physiography or elementary science. And if the new name only frees us from the old, technical, dry-as-dust type of physiography so loved by the instructors of twenty years ago, it is sufficient. But it does more. It gives latitude for individual eccentricities of environment so that Atlantic City children may study their ocean and Paterson youths their automobiles, and who shall say that either has missed the lesson, if both have learned to do their own thinking and discovered something of vital interest to themselves?

### THE ELECTRON THEORY OF VALENCE.

BY R. F. HOLDEN,

*Soldan High School, St. Louis, Mo.*

In the May, 1916, number of SCHOOL SCIENCE AND MATHEMATICS, there appeared an article by Robert W. Boreman on "A Few Theories of Modern Chemistry," in which the author took to task the term, "oxidation." It is certainly true that this term is no more of a philological model than its parent, "oxygen;" but when we point an accusing finger at the latter term, the spirits of Scheele and Priestly moan, and the ghost of Lavoisier forbids!

Oxygen is no longer the "acid producer," and oxidation has long since come to signify a positive increase of valence, whether the element, oxygen, be present or not.

My purpose is not to criticize Mr. Boreman's article, but to reemphasize the great value of the electron theory of valence in considering oxidation and reduction. When Berzelius and Davy proposed their electrical theory of valence, they unfortunately incorporated with it the untenable proposition that the valence of an element must always be one and the same. In spite of that fact, the theory found a good deal of use in some quarters. For example, the topic, "Equations, Rule for Balancing," in Prescottt and Johnston's *Qualitative Chemical Analysis* illustrates such use. By reading the word "electron" where "bond" is written, that topic becomes one with which every teacher of chemistry should be thoroughly familiar. For those that are interested still farther, an article by Nelson, Beans, and Falk<sup>1</sup> may be suggested.

When the theories of chemistry come to be seen in a wider perspective, the ionic hypothesis will appear as a corollary to the electron theory of valence.

<sup>1</sup> See *J. Am. Chem. Soc.* 35, 1810 (1913).

**THE GENERAL SCIENCE SITUATION IN TEXAS.**

BY CARL HARTMAN,

*Adj. Professor of Zoology, The University of Texas.*

Thinking that readers of this Journal, which is widely read throughout this country, might be interested in the progress which general science is making in Texas, the writer has prepared this brief article.

Several scores of Texas high schools, chiefly small ones, have already introduced the subject into their curricula, and doubtless many others have been deterred from so doing because the colleges of the state have not heretofore recognized general science as an accredited entrance unit. This will, however, henceforth be done, as will appear below, by the State University of Texas, and by most of the other colleges of the state.

The movement for securing affiliation in general science was begun in the spring of 1915 when application was made to the Council on Affiliated Schools to consider the matter. A committee of the Council was appointed to study the merits of the subject, and to make a report in the following academic year. This committee consisted of a professor from each of the departments of chemistry, physics, geology, and agriculture, and the writer, who represented the biological departments. All members of the committee have had experience in secondary schools, and are now for the most part actively engaged in research work in their respective fields.

The committee began the study of the problem with some little prejudice against the subject, reputed to be vague and "general," and the arguments which the members of the committee and their colleagues used against the new "fad" are, as was soon learned from a perusal of the current periodical literature on the subject, the same as are generally urged against the subject. The committee studied the available textbooks with care, and also read practically the entire pedagogical literature bearing on the subject. As a result of its deliberations, the committee made a favorable report to the Council with unanimity, urging that affiliation be granted, and stating in the following words some of the reasons that moved them to offer a favorable report.

1. The subject is adapted to the pupil just coming up from the grammar grades.
2. It is designed to awaken interest in science in a way that the more technical or formal sciences cannot do with very young pupils, for general science is organized about the common phenomena of daily experience.

3. It can be made into an extremely useful course, both in preparation for the formal sciences later in the high school course and in preparation for life for those pupils who leave school before graduation.

4. As an intelligent experiment in pedagogics, it promises to further the cause of science teaching in the high school, clearly a desideratum in this age of science when the significance of science to daily life is increasing but the enrollment in science subjects in the high school is suffering a falling off.

5. The fear that the movement is in the direction of making science easy rather than thorough does not seem to be justified by experience; and the committee believes that this subject may be properly safeguarded, as are other subjects, by requiring the attainment of a set standard before affiliation is granted to any school applying for affiliation in this subject.

The Council discussed the report at great length, and finally referred it back to the committee to discuss ways and means of safeguarding the general science unit in case of its recognition by the faculty and Board of Regents. The committee, after considering this phase of the problem, returned the following report:

1. The unit in general science can be safeguarded in precisely the same manner as obtains in the case of other entrance units. It will be subject to the same dangers as other studies—no more and no less. The persons or the committees who pass upon laboratory notebooks and examination papers submitted by the schools, together with the Department of School Visitation, must set the standard in this course as they do in others. The standard in general science can and doubtless will be set as high as other first-year high school subjects.

2. As to the quantity of work to be done, the committee believes, from a careful perusal of the several textbooks available, that the material is quite sufficient for a year's work. In a nine months' school term of five periods a week, it is expected that at least 160 periods would be devoted to recitation and laboratory hours, twenty out of 180 possible hours being counted out for examinations and holidays. Of these 160, eighty would possibly be devoted to recitations and eighty to laboratory work and demonstrations. This makes five pages of the average textbook to be covered in one day. The shortest text contains three hundred pages (nearly four daily), but it is accompanied by the most thorough laboratory guide, and it is the most compact and tersely written text of the series.

3. Laboratory work is regarded by your committee as an essential and indispensable feature of the course in general science. It is not meant, however, that the pupil must himself perform every exercise. Indeed, the majority of the experiments may be performed by the teacher, and observed, discussed, and written up by the pupils. Anyone who knows high school conditions knows the difficulty of conducting laboratory work with large classes and little equipment.

4. The equipment absolutely necessary for conducting a laboratory course in general science is within the reach of any high school, large or small. Few high schools will need any equipment other than what they already have in their other science courses; but there should be available for use in the general science course the equipment of at least one other science, and affiliation should not be granted unless this minimum is available.

5. That the teacher is the most important factor in any course or in any school, your committee fully realizes. The course should be taught by a teacher who is teaching a formal affiliated science, or by one who has had one college course in a physical science and one in a biological science (the B. A. requirement).

It should be pointed out, however, that the science teacher in the vast

majority of high schools already teaches all of the sciences, physical and biological, which the high school offers.

That the teacher strong in a particular science will stress the application of the principles with which he is familiar, stands to reason. The same tendency is reflected in the various textbooks. This is, however, a matter of minor importance as compared with the quality of the work done.

In conclusion, the committee considers the term "General Science" a misnomer, tending to mislead. We fully realize that the term is the one most employed, but hope that "Introduction to Science" or "Elementary Science" may soon replace it.

The means thus presented for safeguarding the general science unit were finally incorporated in a resolution which passed the Council on Affiliated Schools unanimously, and was promptly endorsed by action of the University faculty. Previous to the action of the faculty, the matter was also endorsed by a referendum vote of the superintendents and principals throughout the state. The resolution of the faculty (April, 1916) reads as follows:

Resolved, That one unit of entrance credit be allowed for "Introduction to Science" under the following conditions:

1. That the subject be offered prior to all other sciences except physical geography and physiology.
2. That credit be given to any one candidate for entrance to college for one unit in "Introduction to Science" or for one-half unit in physical geography and one-half unit in physiology and hygiene, and that credit may *not* be given for both of these first-year courses.
3. That there be available for the teaching of "Introduction to Science" first, laboratory equipment for a course in either biology, botany, chemistry, physics, or zoology; and, second, such additional equipment as may be needed for the proper teaching of "Introduction to Science."
4. That the teacher who is giving the course in "Introduction to Science" should either be teaching a course in biology, botany, chemistry, physics, or zoology; or should have credit for at least one college course in the physical sciences and one college course in the biological sciences.

Several points of general interest, not usually mentioned in the current articles on general science, were brought out in the above-mentioned discussions.

1. First may be mentioned the problem of the supply of teachers and the manner in which the objection was answered that general science is too broad a subject for the teacher of average training to handle. Statistics for Texas were gathered, similar to those given by Eikenberry for Illinois (*Sch. Rev.*, 1915) to show that as a matter of *fact* (theories aside) there are few science specialists in the high schools, i. e., teachers who teach only one or two subjects. By November, 1915, 125 affiliated high schools (with 202 science teachers) and fifty-three high schools newly applying for affiliation (sixty-three science teachers) had reported to the Visitor of Schools. These included



most of the large cities, hence the more favorably situated schools in the state. Of these teachers:

Thirteen per cent teach one subject only.

Twenty-two per cent teach one or two subjects only.

Twenty-two per cent teach all of the science offered (science only).

Twenty per cent teach all the science and all the mathematics.

Fifty per cent teach all the science and at least one other subject.

It is thus seen that the majority of science teachers are already teaching a variety of subjects. That this condition will continue is apparent when one considers the fact that the majority of high schools are small, and for this reason can afford only a small faculty in which specialization is out of the question in science. A compilation of statistics taken from *A Directory of Texas High School Teachers*, published by the Department of School Visitation of the University, is interesting in this connection. The list includes the best 240 high schools of the state, and of these about two hundred are on the accredited list, the remaining forty being among the most promising applicants for affiliation. It appears that among these 240 schools,

Twenty per cent have more than ten teachers.

Twenty per cent have six to nine teachers.

Twenty per cent have five teachers.

Forty per cent have three or four teachers only.

The figures speak for themselves. A fair knowledge of the literature on secondary schools convinces the writer that the condition in Texas is not exceptional. He is convinced, therefore, that the universities and colleges are, in the main, failing to take advantage of their opportunity of training teachers for these schools, for the reason that they tend to train specialists rather than high school teachers of science.

It seems, therefore, quite apropos at this point to refer to the views of a certain college faculty committee on the training of teachers, for the suggestions seem to the writer to be sound and helpful. The committee believes that prospective teachers of science (not science specialists, mind you, but undergraduates *who propose to teach*) should be advised to take not much more and no less than about seven-twentieths of their college work in science, viz., three-twentieths in a major subject, two-twentieths in a related first minor, and two twentieths in an unrelated second minor. This is believed to be a better arrangement than a long list of first-year or freshman courses in many sciences, for it requires a number of years in any one science really to learn to use the tools of science and to get a grounding in the methods



of science. The suggested course of study the writer considers a justifiable compromise with the ultra-specialists.

As to whether or not a college course in general science is necessary, it is believed that such a course would be quite superfluous; that a teacher trained in courses as outlined above is also as well trained as can be expected for the teaching of general science. The ideal thus set forth is not high, it is true, but it is so much higher than the present accomplishment that most of us would glory in the attainment of the above mentioned seven-twentieths minimum for high school teachers of science.

2. The second and last matter relates to the displacement of courses now in the curriculum by the introduction of general science. Theoretically, the new study is supposed not to displace anything. Practically, however, it does displace (cf. Taylor, *Sch. and Soc.*, 1916; Lewis, *Sch. Rev.*, 1916). In Texas, physiology and hygiene and physiography are now offered for one-half year each in the vast majority of the high schools. These studies will suffer displacement by the introduction of general science, and each school will have to decide which course is the more worth while. (In Texas, the high school begins with the eighth grade, not the ninth, as in some states.)

The substitution of general science for physiology and hygiene would, in the writer's opinion seem to be justified on these grounds: Personal hygiene is taught in the grades for a number of years, first orally in the primary grades, then from an elementary text on sanitation, later in the grammar school from a more advanced text on physiology and hygiene. It is suggested that this last-mentioned course be made more thorough, and that it be illustrated by demonstrations by the teacher more than is now generally the case. To prevent repetition, general science would displace the physiology in the freshman year; but the displacement is not so serious as would seem at first sight, for the new course includes many fundamental principles applicable to physiology and sanitation, and the pupil gets these from new angles and new points of view. Again, later in his high school course the pupil will have the opportunity to get more physiology in connection with his biology course, which is now coming to be organized on a physiological basis, with life processes as the keynote of the course. These courses would seem to total a sufficiency on the "physiology" side of the pupil's education.

The displacement of physiography is justified on the ground

that general science takes over the fundamental parts of the subject, and, as one of our committee put it, general science will continue to give those topics of physiography which have been the *best taught* in the past. It is expected that the new science will accomplish in a more efficient way what has been accredited to physiology and physiography in the past, namely, to interest the first-year pupil in the common phenomena of everyday life.

For these reasons, and others that have been mentioned repeatedly in the current literature on the subject, it would appear that general science is well worth trying, and that certainly it does not deserve being thrown overboard merely on account of its unfortunate name.<sup>1</sup>

<sup>1</sup>In the official bulletins of the University of Texas, the new course is designated "Introduction to Science" instead of "General Science."

#### A SYSTEM OF REMOTE CONTROL FOR AN ELECTRIC TESTING LABORATORY.

In a laboratory in which a large number and variety of electrical instruments are tested, it is important that means be provided for the rapid and accurate control of the electric generators which provide the current for testing. In *Scientific Paper, No. 291*, by P. G. Agnew, W. H. Stannard, and J. L. Fearing, published by the Bureau of Standards, an elaborate system of this kind, which is in use at the Bureau, is described. The control rheostats are not handled by the observers directly, but are operated by small motors which are controlled from any one of several laboratory rooms by means of small, multiple lever switches.

#### TIN IN LANDER COUNTY, NEV.

Tin ore has recently been found in the extreme northern part of Lander County, Nev., in an unnamed short range of hills, twenty miles north of Battle Mountain, a town on the Southern Pacific system. It was discovered by chance by an employee of the Russell cattle ranch, in which the range is situated, who had picked up from the alluvial wash at the base of the range a piece of curious-looking "rock." What the substance was, however, remained unknown until a mining engineer who had been in Mexico chanced to see it at Battle Mountain and recognized it as "wood tin," a name given to the form of the natural oxide of tin that is characterized by a concentric banding resembling the annual growth rings of wood. Search was immediately made for the bed rock source of the ore, which has already been found at several places in a belt two miles long. At the request of Senator Pittman, these occurrences were recently examined by Adolph Knopf, a geologist of the U. S. Geological Survey, Department of the Interior.

The ore occurs in narrow veinlets in rhyolite lavas, which were erupted in middle Tertiary time. In places, the veinlets are sufficiently numerous to form low-grade lodes, but because of the small development work so far done, not much is known as to the size, extent and richness of these lodes. The indication of the stronger lodes, taken in connection with their geology, are, in the opinion of government geologists, such as to warrant further exploration.

**MATHEMATICS AND EFFICIENCY IN SECONDARY SCHOOL WORK—A REPLY.**

BY WILLIAM ASKER,

*University of Washington, Seattle.*

The March, 1916, issue of this Journal contains an article under the above heading, by Prof. Robert E. Moritz of the University of Washington, in which he makes a plea for giving mathematics a large place in secondary instruction. As this problem is a very important one, it deserves to be treated from different points of view, and I am taking the liberty of trying to show the one-sidedness of Dr. Moritz's argument. I do this not as a mere student of educational theories, but as a teacher of secondary school mathematics.

The gist of the article by Dr. Moritz is contained in the following passage: "We are now in a position to understand why the study of mathematics must necessarily occupy a large place in secondary instruction. It is not because the theorems of geometry or the rules of algebra as such are of any great value to the high school graduate, though it will be admitted that they are indispensable to every scientific pursuit and to countless occupations and professions. The mere knowledge of the Pythagorean triangle relation or of the binomial theorem is probably of less immediate value to the average graduate than the knowledge of how to sharpen a knife or to sew on a button. But as an exercise in fundamental thought processes, they are invaluable to every individual, no matter what his ultimate work in life may be."

In other words, Dr. Moritz bases his opinion upon the old and now generally abandoned doctrine of formal discipline. The arguments he offers consist of quotations from various writers on educational questions, from Plato to more recent ones. But Dr. Moritz has been rather unfortunate in selecting his authorities; and I will permit myself to give one or two citations from Plato and Locke, showing that they might as well be referred to by opponents of the doctrine of formal discipline if we select suitable passages. Says Plato: "All this is but the prelude to the actual strain that we have to learn. For you surely would not regard the skilled mathematician as a dialectician?" Assuredly not. He said: "I have hardly ever known a mathematician who was capable of reasoning."<sup>1</sup> In his *Conduct of the Understanding*, Locke says: "We should always remember that the faculties

<sup>1</sup>*Republic* (Jowett's translation), p. 581.

of our souls are improved and made useful to us, just after the same manner as our bodies are. Would you have a man write or paint, dance or fence, well, or perform any other manual operation dextrously and with ease? Let him have ever so much vigor and activity, suppleness, and address naturally, yet nobody expects this from him unless he has been used to it, and has employed time and pains in fashioning and forming his hand, or outward parts, to these motions." And again, in *Thoughts on Education*: "I hear it is said that children should be employed in getting things by heart to exercise and improve their memories. I could wish this were said with as much authority or reason as it is with forwardness of assurance, and that this practice were established upon good observation more than old custom. For it is evident that strength of memory is owing to a happy constitution and not to any habitual improvement got by exercise. Is it not the same with the other faculties?"

But it is not my intention to base any argument upon quotations from authorities. I cite these passages only to demonstrate the value thereof. And yet this kind of argument is the only one employed by Dr. Moritz in his article. He quotes from his authorities passages that sustain his opinion, and he is ready with his conclusion that we should give a great deal of mathematics to all students in the secondary schools as an exercise of their reasoning power. His article would have been more valuable if he had presented the views of representatives of both sides, and weighed their arguments against each other.

The question of formal discipline has caused much dispute. While the older educational schools generally accept the doctrine of formal discipline, it has been attacked by modern writers—most vigorously, perhaps, by Thorndike, who holds that training the mind means the development of thousands of particular independent capacities. In a recent work, *Psychology of High School Subjects*, Judd discusses the controversy, and finds the truth in the golden mean. No subject can claim for itself the monopoly of training the mind. The testing stone is the question: Is it taught in such a way as to give a generalized experience? No subject that becomes an end in itself does this. In other words, we must study from a philosophical point of view. What we must guard against is formalism in content as well as in mode of procedure. We must make the subject matter of vital interest, and the best way of doing so is by application. This means efficiency.

Now, let us apply these principles to the teaching of mathematics. Nobody would deny that mathematics is of great practical value. It is needless to point out how one science after another adopts mathematical methods for solving its problems, to say nothing of its applications in technical and business life. But do we show this to our pupils in the high school? No, we rather let them understand that, although it would be much more useful for them to learn "how to sharpen a knife or to sew on a button," yet we insist on their studying mathematics as "an exercise in fundamental thought processes," and as "the most efficient agency for acquiring the power of quick attention and prolonged concentration of mind." We do not even suggest to them the relation between the two branches of mathematics, geometry and algebra, treating them as two altogether different subjects. While interest is a very important condition for learning with children, it is still more important with adolescents. And who will blame an adolescent whose whole soul and body are crying for action, for being unwilling to sit down on the school bench and study mathematics or any other subject that seems useless to him? We must take into account the nature of the youth if we want our school work to be efficient. If, instead of pure algebra or dry geometrical theorems, we gave problems related to the daily life or interests of the students, much would be gained. And this would offer an opportunity for acquiring generalized experience much more valuable for the training of the mind than the mathematics we generally give in high schools. I remember one case where I had to coach a boy in trigonometry, a subject that he thought of no value to him. I found out that his ambition was to become an artillery officer. I gave him a few problems relating to military science and that changed his mind. Then he saw that trigonometry was indispensable to his future profession, and in spite of his poor ability in mathematics he spared no effort in struggling through his course.

But even if much could be gained by modifying the topics to be studied and our methods of teaching mathematics, another question is if it is advisable to require every high school student to take this subject two or three semesters. Every experienced teacher knows that to many students mathematics is a very difficult subject. And if we admit that mathematics has no monopoly in "training the reasoning power," it seems as if it would be much more efficient to allow a greater freedom of electing subjects in the high school. No doubt, a student interested, for instance, in



biology would profit much more by being permitted to devote a good deal of his time to this subject than by being compelled to study mathematics, which would be merely a drudgery to him.

I am not underestimating the great value of mathematics, as a high school subject, if properly taught, but we must guard against one-sidedness and formalism. Our schools can never reach maximum efficiency until we realize the importance of the maxim, *Non scholae, sed vitae*.

### A METHOD OF COMPUTING CUBE ROOT.

By D. E. DAVIS,

*Mt. Auburn, Ill.*

I read Mrs. M. W. Arleigh's article on square root in the November, 1916, issue of *SCHOOL SCIENCE AND MATHEMATICS*, and at once thought of a similar method of finding a cube root of a number based on the common method of factoring the difference of two cubes.

Let  $x$  and  $y$  be any numbers.

$$x^3 - y^3 = (x - y)(x^2 + xy + y^2).$$

$$x^3 = y^3 + (x - y)(x^2 + xy + y^2).$$

When  $x - y = 1$ ,

$$x^3 = y^3 + 1(x^2 + xy + y^2).$$

When  $x - y = 2$ ,

$$x^3 = y^3 + 2(x^2 + xy + y^2).$$

When  $x - y = n$ ,

$$x^3 = y^3 + n(x^2 + xy + y^2).$$

An example makes the method clear.

Find the cube root of 788,889.024.

By inspection,	90 <sup>3</sup> =	729,000.
$x^2 = 92^2$	=	8,464
$xy = 92 \times 90$	=	8,280
$y^2 = 90^2$	=	8,100
$x^2 + xy + y^2$	=	24,844
$x - y = 2$		2
	49,688 =	49,688
	92 <sup>3</sup> =	778,688.
$x^2 = 92.4$	8,537.76	
$xy = 92 \times 92.4$	8,500.8	
$y^2 = 92^2$	8,464	
	25,502.56	
$x^2 + xy + y^2$	.4	
$x - y = .4$	10,201.024 =	10,201.024
<i>Ans.</i> 92.4 for	92.4 <sup>3</sup> =	788,889.024

The pupil should make out a table of cubes from one to ten, and from that he can find the first cube in the ordinary manner. The squares and products can be found by Mrs. Arleigh's method.



This method seems to me to be as easy to learn as the one in general use, and it has two advantages. The pupils can see more of a reason for the method, and it keeps before them the fact that the cube root of a number is one of three equal factors.

Any root of a number may be found by a similar method.

### ANOTHER PROOF OF THE LAW OF TANGENTS.

By A. M. HARDING,

Fayetteville, Ark.

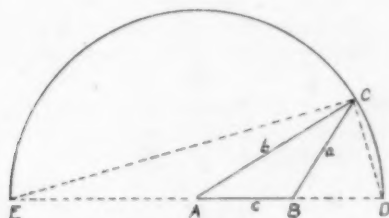
In the December number of *SCHOOL SCIENCE AND MATHEMATICS*, Mr. R. M. Mathews has outlined several simple proofs of the law of tangents, and has suggested the much-needed extension in definition,

$$\sin a = \sin (180^\circ - a), \cos a = -\cos (180^\circ - a),$$

when  $a$  is an obtuse angle.

This extension in definition is made in the Harding and Turner *Plane Trigonometry* (G. P. Putnam's Sons), published in March, 1915, and upon it is based the proof outlined below:

Suppose  $b > c$ .



With center A and radius AC, describe a semicircle meeting AB, in D and E; join CD, CE.

Then  $AC = AD = AE$ , hence  $EB = b + c$  and  $BD = b - c$ .

Also, by elementary geometry,  $\angle ACD = \angle ADC$  and  $\angle ACD + \angle ADC = 180^\circ - A = B + C$ . Hence  $\angle BCD = \frac{1}{2}(B + C)$ .

Again,  $\angle BCD = B - \angle BDC = B - \frac{1}{2}(B + C) = \frac{1}{2}(B - C)$ .

Now the angle ECD is a right angle, since the arc ECD is a semicircle.

hence

$$\angle BEC = 90^\circ - \angle BDC = 90^\circ - \frac{1}{2}(B + C),$$

and

$$\angle ECB = 90^\circ - \angle BCD = 90^\circ - \frac{1}{2}(B - C).$$

Thus

$$\frac{b - c}{a} = \frac{BD}{BC} = \frac{\sin BCD}{\sin BDC} = \frac{\sin \frac{1}{2}(B - C)}{\sin \frac{1}{2}(B + C)}$$

and

$$\frac{b + c}{a} = \frac{\sin ECB}{\sin BEC} = \frac{\cos \frac{1}{2}(B - C)}{\cos \frac{1}{2}(B + C)}.$$

Hence, by division,

$$\frac{b - c}{b + c} = \frac{\tan \frac{1}{2}(B - C)}{\tan \frac{1}{2}(B + C)}.$$

A FAIRY TALE.<sup>1</sup>

BY ZOE FERGUSON,

*Central High School, St. Joseph, Mo.*

Once upon a time there was a Boy who was a Freshman in High School. One dark night he became lost in the Algebra woods. It was very dark, and he was much afraid. Finally he thought he saw a little path and started to follow it.

He had not gone far when he saw a fearful looking creature approaching. He was so frightened he could scarcely stand, but he asked in trembling tones, "Who are you?"

"My name is Factor Theorem," the creature replied in a gruff voice. "I have long wanted to become acquainted with the Factor Theorem," said the Boy, with rising courage; "I am glad I met you. Won't you please help me to get acquainted with some more of the Algebra people?"

"With pleasure. Here comes Theory of Exponents," said his new friend. "He is a very ugly looking person," said the Boy. "He is a very clever fellow, and I am sure you will like him when you know him better."

They went on through the woods, and the Boy began to feel that it was growing lighter. They saw a number of Algebra folk as time passed, and all of them seemed to be going in the same direction. The boy became much interested, and at last plucked up courage to ask where they were going.

"We are going to a Mathematical Feast," cried Ratio, Proportion and Variation in one breath. "Won't you come?" "Sure!" said the Boy. "I'd like to see what you eat."

Soon they came to the place where the feast was to be held. The cloth was laid on the Multiplication Table, and was decorated with a series of Progressions.

All of the Algebra people sat at this table except the Logarithms who had a table to themselves, and the Harmonical Progressions who furnished the music for the occasion.

On the large table the centerpiece was of Quadratic Equations, neatly arranged.

The Boy was given the seat of honor, and as a favor he found in front of his plate a curious mechanical toy. He asked Theory of Limits, whom he had seen put it there, what it was, and was told that it was a "Variable-approaching-a-limit." "Well, if that isn't the limit!" said the Boy.

He then asked Factoring, who sat on his right hand, why the Logarithms had a table to themselves. "They can do so many things that they are quite stuck up and don't care to associate with the common herd. As far as I am concerned, I can get along without their help," was the reply.

Just then a small army of waiters appeared. There was a good deal of sameness in their appearance, and the boy asked one of them his name. "I am called Things-equal-to-the-same-thing," said the waiter. "You see we are the Axioms. They are self-evident, and it is our duty to help these poor Theories. Some of them would have a hard time to prove their demonstrations without us," he added, swelling out his chest.

<sup>1</sup>The writer has found this little story useful in "vitalizing" high school mathematics.

Then the feast began. The Boy found the courses of Addition, Subtraction, Multiplication, and Division tasted very much like his mother's sugar cookies, only they were cut in different shapes.

The Square and Cube Roots he found very palatable, as well as Equations served in several different styles. At one side of the table under some trees, a platform had been erected, and Hindoo Method told the Boy that it was the custom for the people to give Demonstrations on this for the entertainment of their guests.

Factor Theorem and Factoring gave a sleight of hand performance, and the way they juggled Binomials, Trinomials, and Polynomials almost took away the Boy's breath.

Binomial Theorem gave a very complicated exhibition of his powers, and praised Sir Isaac Newton so much that the Boy began to wonder who Sir Isaac was.

Two curious looking little creatures mounted the platform and announced themselves as the Incommensurable Ratios, but what they said and what they did the Boy could not understand. The next was a character sketch by Square and Cube Root. The Boy was much interested, and leaned forward with eyes and mouth wide open. Cube Root let a decimal point fly out of his hand. The Boy thought it was a paper wad and jumped. Then he heard his mother say, "Have you your lessons? You have been asleep an hour."

"Gee!" said the Boy, "I wish I could put in an hour a day that way on Algebra every day."

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#### A GREAT TEACHER'S VOW.

We were recently reading in the *Bostonia*, a quarterly publication of the Boston University, the sentiments expressed below, by that prince of teachers, Lyman C. Newell, of Boston University. They hit the nail squarely on the head, and, if teachers would abide by the ideas given, the quality of their work would be greatly enhanced. This Journal considers it an honor to have the author of these sentiments on its Board of Associate Editors.

"I will see the good in all pupils and lead them on to higher attainments.

"I will be patient and forbearing, confident in the belief that kindness and generosity will ultimately triumph.

"I will scorn error, deceit, and all forms of falsehood, persistently foregoing sarcasm and injustice.

"I will claim all nature as my heritage, and spend a portion of each day quietly in God's open air.

"I will hold daily communion with my own soul.

"I will accept my remuneration, however small, without envy, complaint, or discouragement, never forgetting that a teacher is a leader into the higher life, and not merely a wage-earner.

"I will work each day in unshaken assurance that peace and power come in full measure to all who are ready for the truth."

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#### ERRATUM

In the January number a mistake was made in the Eimer and Amend advertisement. The third office should be OTTAWA, CANADA, instead of ATLANTA, GA.

## RESEARCH IN PHYSICS.

By Homer L. Dodge,

Iowa City, Iowa.

*The rapidity with which physical science develops makes it impossible for textbooks to be strictly up-to-date. Information concerning recent discoveries and new concepts must, therefore, be supplied by the teacher. Here lies the opportunity for the teacher to make physics a living, changing, developing science, and not something fixed and forever determined. This department will attempt to deal with such material as is sure to find its way into the next editions of physics texts.*

## THE CAUSES OF THE REGULARITY IN WAVE TRAINS OF LIGHT.

In the December number, it was shown that white light is probably not made up of regular series of simple wave trains of different frequencies, as is ordinarily supposed, but is, rather, a series of light pulses, corresponding to noises in sound. The interference effects produced when gratings and prisms are employed are now explained as the result of a regularity in the wave train, imposed by the action of the instruments themselves.

There are, however, cases of interference which are on a slightly different footing. For instance, Michelson with his interferometer has obtained interference between waves from the mercury vapor lamp, the lengths of path of which differed by as much as 540,000 wave lengths. This shows a regularity in the wave train which cannot be explained as an effect due to the instrument, since the interferometer does not in any sense correspond to a grating, and although it may embody lenses the path through the glass is by no means sufficient to explain the regularity observed. This remarkable regularity has usually been taken to imply that an atom of mercury could sustain vibrations with such persistency that after half a million of them it would be in action as vigorously as ever, and would be, moreover, radiating all this time without any change of phase.

This appears hardly probable to Sir Joseph Thomson, who does not find it easy to realize how the necessary conditions for the interference could be sustained, if the whole of the radiation were produced by a single atom. Such atoms are, for example, continually coming into collision with other atoms, and the consequent shock alters the phase of the radiation and destroys the regularity of emission necessary for interference. It appears, however, that such disturbances are relatively unimportant as the interval between collisions is very large in comparison with the time taken to emit half a million vibrations.

A radiating atom is, however, subject to shocks of another kind. Each is surrounded by others emitting light, and to this light the atom is very absorbent. Consequently, a possible explanation of the regularity of the wave train is that the necessary precision of phase is produced by the mutual interaction of a vast number of luminous centers, each particular atom being excited by the main stream of light and forced to vibrate in unison with it. As one atom ceases to vibrate, another begins, the phase at which it starts being fixed by the stream of light in which it

lies. Some such view is necessary if the regularity in the wave train is to be attributed to a regularity in the vibration of the luminous centers.

There is, however, evidence that the regularity of the Michelson wave train is not to be attributed to any regularity in the radiating atoms of mercury, but to the influence of the medium by which they are surrounded. In fact, the mercury atoms active at any instant are surrounded by mercury vapor, and as this vapor has a very intense dispersive power for mercury light, the effect in question may be due to action of the vapor and not to the character of the actual vibrators. A satisfactory explanation of the mechanism of such an action would require more space than is here available.<sup>1</sup> The general nature of the phenomena can, however, be illustrated by a model, consisting of a spring, one end of which is attached to the top of a vertical standard and the other to a crosshead reciprocated by a crank. A weight is secured to the spring at mid-length. Such a weighted spring has a natural frequency of its own, but can be thrown into forced vibrations by rotation of the crank. But the motion would be small except when the rate of rotation of the crank corresponded to the natural period of the system. If the two periods were identical, the weight and spring would vibrate with great violence. If the crank were to be rotated with an irregular, jerky motion, the system would respond very strongly to that part of the motion which might be regarded as being of its own natural frequency.

Now the motion of the crank can be regarded as corresponding to the vibration of the luminous particle, and the vibration of the weight to that of an atom of the surrounding vapor. Even though the motion of the radiating atoms is not regular, the greater part of the energy will be associated with a frequency of vibration equal to the natural frequency of the mercury atom, and this energy will be strongly absorbed by even a very thin layer of gas, and will be reemitted as light of a very regular form. Suppose each vibrator should make only a few oscillations. A large part of the radiated energy would be absorbed by the mercury vapor around the luminous centers and reemitted in the form of a pure wave of great regularity.

This ability of even a small amount of gas to scatter light of a particular frequency is shown in an experiment due to Professor R. W. Wood. When the light from a sodium flame is directed into a bulb containing sodium vapor at a pressure even as low as .001 mm. of mercury, the vapor will glow with an intense light. In fact, its reflecting power is so great that a screen of highly reflecting material may be made to disappear entirely in the intense glow produced, as the sodium atoms resonate to the sodium light falling upon them. It is thus evident that the train of waves in Michelson's experiment might have been separated from the other components of the disturbance by the action of the mercury vapor around the luminous centers.

There is yet another phenomenon, the characteristics of which depend upon the regularity of the wave train of light and which has been taken to indicate a regularity in the vibration of the luminous source. It can be shown that irregularities in a wave train will result in a broadening of spectral lines. If a vibrating system does not vibrate for a long period, its effect cannot be represented by a simple train of waves. For example, a piano string, when freely vibrating, sends

<sup>1</sup>Sir J. J. Thomson in his lectures at the Royal Institution gave a remarkably clear exposition of the principles involved, using mechanical models to illustrate the passage of light through a dispersive medium. The particular lecture in question will be found reported in full in *Engineering*, 101, 282, 1916, and the *Scientific American Supplement*, 81, 309, 1916. A treatise on optics should also be consulted.



out a simple harmonic vibration, but at the moment the string is struck or stopped there is a noise due to waves of many different frequencies. The corresponding "noise" in the case of light cannot be detected so easily. In fact, a diffraction grating or some form of spectroscope is necessary. Such an instrument is able to pick out the vibrations of a certain frequency, and concentrate them into a single spectral line. If the range of frequency is very sharp, the line will be very sharp. Now the starting and stopping of a wave train corresponds to the addition of light of slightly different frequency to that of the train itself. This additional light will tend to widen the line. The longer the time the vibrator is in regular motion, the less will be the broadening. The results of measurements of this kind indicate that in ordinary spectroscopic observations the train received must have consisted of at least 100,000 waves. But this does not necessarily imply that the actual source has maintained its vibration unaltered for a corresponding time. If this is not the case, we must account in some other way for the presence of wave lengths slightly different from that of the main train.

As is well known, the atoms containing the vibrators which are the cause of the light are themselves in rapid motion. At times they are moving toward the observer, and at times away. When the source of light is moving toward the observer, the light waves crowding upon each other result in a slightly shorter wave length than the normal. In a similar way, a longer wave length is produced when the atoms are moving in the contrary direction. This is the well-known Doppler effect, familiar also in the case of sound waves, in which instance the pitch of the sound reaching the ear from a vibrating source depends not only upon the frequency of the source, but also upon the velocity of the source with respect to the observer. Lord Rayleigh has demonstrated that the actual breadths of spectral lines can be adequately explained by the Doppler effect. Thus evidence of this sort can give no information concerning the regularity of the vibrators which produce the light.

If we accept Professor Thomson's viewpoint, we are led to the following conclusions:

1. White light is composed, not of an indefinite number of regular wave trains, each sustained for a relatively long time, but rather of countless light pulses or "noises." The regularity observed with the use of diffraction gratings and instruments involving prisms and lenses is not in the incident light, but is impressed upon the light by the action of the instruments upon the irregularly shaped waves impinging upon them.

2. Monochromatic light when it reaches the instruments of observation is in the form of wave trains, regular for several thousand wave lengths. But this regularity is not due to long-continued regularity in the motion of the vibrators of the original luminous source. While it may be that the vibrators are fired off in phase with the stream of light, it is probable that the regularity can be accounted for by the action of the dispersive layer of gas immediately surrounding the luminous atoms.

3. No optical effects require for their explanation the assumption of sustained regularity in the vibration of the original light source.

Equally interesting and far-reaching conclusions are arrived at by Professor Thomson from a consideration of the electrical phenomena associated with radiating atoms and electrons. These will be dealt with in future issues.

#### CONSTANTS OF RADIOACTIVITY.<sup>2</sup>

Radioactivity is exhibited by certain elements of high atomic weight.

It is a property of the atom itself, and does not depend in any way upon the chemical combination in which the atom is found. Nor is it affected by the physical conditions controlling ordinary reactions. Radioactive bodies emit  $\alpha$ ,  $\beta$ , and  $\gamma$  rays.  $\alpha$  rays are easily absorbed by thin metal foil, a sheet of paper, or a few centimeters of air. They are positively charged atoms of helium, emitted with a velocity of about one-fifteenth that of light. They are deflected but very slightly by intense electric and magnetic fields.  $\beta$  rays are, on the average, more penetrating. They are negatively charged particles, or electrons, projected with nearly the velocity of light, and are identical in type with the cathode rays in a vacuum tube. Accordingly, on account of their small mass, they are easily deflected by electric and magnetic fields.  $\gamma$  rays are extremely penetrating and non-deviable. They are in many respects analogous to very penetrating X-rays. The rays from radioactive substances produce ionization of gas, act on the photographic plate, excite phosphorescence, and produce certain chemical effects.

In the three radioactive series listed in the accompanying table, each succeeding product results from the transformation of the preceding product (except where the name of a substance is indented to indicate that it is a branch product.) When a change is accompanied by the ejection of an  $\alpha$  particle (helium, atomic weight = 4), the atomic weight decreases by 4. The italicized atomic weights are thus computed.  $\beta$  rays, being electrons, can be neglected in this connection.

The activity of a radioactive substance falls off according to an exponential law. This follows from the fact that the activity depends directly upon the amount of the original substance still unchanged and must, therefore, fall off less rapidly as time goes on. If  $I_0$  is the original activity, and  $I_t$  is the activity at any time  $t$ , then  $I_t = I_0 e^{-\lambda t}$ , in which expression  $e$  is the natural base of logarithms, and  $\lambda$  is the constant of the radioactive substance.

The expression  $q = q_0 e^{-\lambda t}$  may likewise be employed to determine the amount of substance still unchanged. After a certain length of time (equal to  $.6931/\lambda$ ), there will remain but one-half of the original substance unchanged. This time,  $P$ , is called the period of transformation.

As will be observed from the table, the periods of the various substances vary greatly. Although some have long periods in many cases the decay is very rapid. Consequently a mass of pure substance cannot remain free from contamination by its own disintegration products. Each of these products will contribute its share to the total activity and when this activity becomes constant the substance is said to be in equilibrium with its products.

The Congress of Radioactivity and Electricity, Brussels, 1910, appointed a committee to arrange for an international radium standard. Mme. Curie's standard of 21.99 mg. of pure Ra chloride, sealed in a thin glass tube, was accepted, and is preserved in the Bureau international des poids et mesures at Sèvres, near Paris.

#### CONSTANTS OF RADIOACTIVITY.

$P$  = period of transformation (the time required for one-half of the substance to transform).

$\lambda$  = transformation constant.  $I = I_0 e^{-\lambda t}$ .  $\lambda P = \log 2 = .6931$ .

$V\alpha$  = initial velocity of  $\alpha$  rays in cm./sec.

$V\beta$  = velocity of  $\beta$  rays in terms of velocity of light ( $3 \times 10^{10}$  cm./sec.).

\*Compiled from the *Physical Review*, N. S., 7, 392, 1916; the Smithsonian Tables and other sources.

Substances.	Atom- ic w'gts.	P.	$\lambda$	Rays.	$V_a$ cm./sec.	$V_\beta$ Light=1.
<i>Uranium—Radium Group.</i>						
Uranium 1 .....	238.2	$5 \times 10^{19}$ yr.	$4.3 \times 10^{-18}$	$\alpha$	$1.36 \times 10^9$	.....
Uranium X <sub>1</sub> .....	234.2	24.6 d.	$3.3 \times 10^{-7}$	$\beta, \gamma$	.....	Wide Range
Uranium X <sub>2</sub> .....	234.2	1.15 min.	0.01	$\beta, \gamma$	.....	.52, .65
Uranium 2 .....	234.2	$2 \times 10^6$ yr.	$1.1 \times 10^{-14}$	$\alpha$	$1.44 \times 10^9$	.....
Uranium Y .....	230.2	25.5 hrs.	$7.5 \times 10^{-6}$	$\beta$	.....	.....
Ionium .....	230.2	$10^6$ hrs.	$2.2 \times 10^{-13}$	$\alpha$	$1.47 \times 10^9$	.....
Radium .....	226	1,730 yrs.	$1.26 \times 10^{-11}$	$\alpha, \beta, \gamma$	$1.50 \times 10^9$	.....
Ra Emanation .....	222	3.85 d.	$2.08 \times 10^{-6}$	$\alpha$	$1.62 \times 10^9$	.....
Radium A .....	218	3.0 min.	$3.85 \times 10^{-3}$	$\alpha$	$1.70 \times 10^9$	.....
Radium B .....	214	26.7 min.	$4.33 \times 10^{-4}$	$\beta$	.....	.36 to .74
Radium C <sub>1</sub> .....	214	19.5 min.	$5.93 \times 10^{-4}$	$\alpha, \beta, \gamma$	$1.92 \times 10^9$	.80 to .98
Radium C <sub>2</sub> .....	210?	1.4 min.	$8.3 \times 10^{-3}$	$\beta$	.....	.....
Radium C' .....	210	$10^{-6}$ sec.?	$7 \times 10^{-5}$	$\alpha$	.....	.....
Radium D .....	215	15.83 yr.	$1.39 \times 10^{-9}$	$\beta, \gamma$	.....	.33, .39
Radium E .....	213	4.85 d.	$1.66 \times 10^{-6}$	$\beta, \gamma$	.....	Wide Range
Polonium (RaF) .....	209	136 d.	$5.90 \times 10^{-8}$	$\alpha, \beta?, \gamma$	$1.58 \times 10^9$	.....

*Actinium Group.*

Actinium .....	A	200 yrs.?	$1 \times 10^{10}?$	$\alpha?$	$1.54 \times 10^9$	.....
Radioactinium .....	A	18.88 d.	$4.25 \times 10^{-7}$	$\alpha, \beta, \gamma$	$1.62 \times 10^9$	.....
[Radioactinium/]? .....	.....	60 hr.?	$3.2 \times 10^{-6}?$	$\alpha?$	$1.67 \times 10^9$	.....
Actinium X .....	A-4	11.4 d.	$7.6 \times 10^{-7}$	$\alpha$	$1.63 \times 10^9$	.....
Act. Emanation .....	A-8	3.9 sec.	0.18	$\alpha$	$1.78 \times 10^9$	.....
Actinium A .....	A-12	.002 sec.	350	$\alpha$	$1.85 \times 10^9$	.....
Actinium B .....	A-16	36.1 min.	$3.2 \times 10^{-4}$	$\beta, \gamma$	.....	.....
Actinium C <sub>1</sub> .....	A-16	2.15 min.	$5.37 \times 10^{-3}$	$\alpha, \beta?$	$1.74 \times 10^9$	.....
Actinium D .....	A-20	4.71 min.	$2.26 \times 10^{-3}$	$\beta, \gamma$	.....	.....
Actinium C' .....	A-20	.001 sec.	700	$\alpha$	$1.87 \times 10^9$	.....

*Thorium Group.*

Thorium .....	232.4	$1.5 \times 10^{10}$ yr.	$1.2 \times 10^{-18}$	$\alpha$	$1.41 \times 10^9$	.....
Mesothorium 1 .....	228.4	5.5 yr.	$4.0 \times 10^{-9}$	.....	.....	.....
Mesothorium 2 .....	228.4	6.2 hr.	$3.1 \times 10^{-5}$	$\beta, \gamma$	.....	.....
Radiothorium .....	228.4	2.02 yr.	$1.09 \times 10^{-8}$	$\alpha$	$1.58 \times 10^9$	.....
Thorium X .....	224.4	3.64 d.	$2.20 \times 10^{-6}$	$\alpha$	$1.64 \times 10^9$	.47
Th. Emanation .....	220.4	54 sec.	0.0128	$\alpha$	$1.72 \times 10^9$	.....
Thorium A .....	216.4	0.14 sec.	5.0	$\alpha$	$1.80 \times 10^9$	.....
Thorium B .....	212.4	10.6 hr.	$1.8 \times 10^{-5}$	$\beta, \gamma$	.....	.63, .72
Thorium C <sub>1</sub> .....	212.4	60 min.	$1.9 \times 10^{-4}$	$\alpha, \beta$	$1.70 \times 10^9$	.....
Thorium D .....	208.4	3.1 min.	$3.7 \times 10^{-3}$	$\beta, \gamma$	.....	.3, .4, .93
Thorium C' .....	208.4	$10^{-11}$ sec.?	$7 \times 10^{10}?$	$\alpha$	$2.07 \times 10^9$	.....
Potassium .....	39.1	?	?	$\beta$	.....	.....
Rubidium .....	85.5	?	?	$\beta$	.....	.....

REMARKS: The emanation in each group is an inert gas, condensing under low pressure at about  $-150^\circ \text{C}$ .

Actinium is probably a branch product of the uranium series.

One gram of uranium emits  $2.37 \times 10^4 \alpha$  particles per sec. One gram of radium in equilibrium emits  $13.16 \times 10^{10} \alpha$  particles per sec.

The total number of ions per second due to the complete absorption in air of the  $\beta$  rays due to 1 gram of radium is  $9 \times 10^{14}$ ; to the  $\gamma$  rays,  $13 \times 10^{14}$ .

The total number of ions due to the  $\alpha$  rays from 1 gram of radium in equilibrium is  $2.56 \times 10^{16}$ . If it be assumed that the ionization is proportional to the energy of the radiation, then the total energy emitted by radium in equilibrium is divided as follows: 92.1 parts to the  $\alpha$ , 3.2 to the  $\beta$ , 47 to the  $\gamma$  rays.

The range, in air (760 mm.,  $15^\circ\text{C}$ .), of the  $\alpha$  rays emitted by the various substances varies between 2.5 cm. for uranium 1 and 8.6 cm. for thorium C'. Similarly, the kinetic energy varies from  $.65 \times 10^{-5}$  to  $1.53 \times 10^{-5}$  ergs, and the whole number of ions produced by the  $\alpha$  particle from  $1.26 \times 10^5$  to  $2.9 \times 10^5$ .

#### *The Production of a Particles (Helium).*

Radioactive substance (1 gram.).	$\alpha$ particles per sec.	Helium per year.
Uranium .....	$2.37 \times 10^4$	$2.75 \times 10^{-5}$ cu. mm.
Uranium in equilibrium with products ...	$9.7 \times 10^4$	$11.0 \times 10^{-5}$ cu. mm.
Thorium in equilibrium with products ...	$2.7 \times 10^4$	$3.1 \times 10^{-5}$ cu. mm.
Radium .....	$3.4 \times 10^{10}$	39 cu. mm.
Radium in equilibrium with products ....	$13.6 \times 10^{10}$	158 cu. mm.

#### *Heating Effect of Radium and Its Emanation—Heating Effect in Gram-Calories per Hour per Gram of Radium.*

	$\alpha$ rays.	$\beta$ rays.	$\gamma$ rays.	Total.
Radium .....	25.1	..	..	25.1
Emanation .....	28.6	..	..	28.6
Radium A .....	30.5	..	..	30.5
Radium B+C .....	39.4	4.7	6.4	50.5
Totals .....	123.6	4.7	6.4	134.7

### PATENTS ISSUED ON COLLOIDAL BITUMENS.

United States patents have just been issued to Clifford Richardson on an improved "bituminous substance," and on the process by which this product is manufactured. Similar patents have also been granted in Canada, Great Britain, France, and Italy. It is believed that these are the first patents covering a product and process involving the introduction of colloidal matter into bitumens of all types. According to the inventor, he obtains "an increased degree of body or stability in these bituminous substances, by means of the addition to, and intimate and uniform dispersion through, the bituminous substance of a proper proportion of a substance in the state of a disperse colloid." The process consists in the introduction of clay in the form of a colloidal aqueous paste, and combining this paste with the bitumen in such a way that when the water is subsequently driven off, the bitumen forms the continuous phase of the colloidal material.

The products resulting from this method of incorporating clay in colloidal form with bitumen has markedly different properties from products into which the mineral matter is introduced in the form of a dry powder. The products made by the Richardson method range all the way from materials resembling vulcanized rubber, to plastic, but at the same time very stable, mixtures suitable for paving and many other uses.

**REPORT OF THE SIXTEENTH MEETING OF THE CENTRAL  
ASSOCIATION OF SCIENCE AND MATHEMATICS  
TEACHERS, HELD AT THE UNIVERSITY  
OF CHICAGO, DECEMBER 1 AND 2, 1916.**

GENERAL MINUTES.

The sixteenth annual meeting of the Central Association of Science and Mathematics Teachers was held at the University of Chicago. It was most fitting that such a meeting should be held in the atmosphere and within the walls of an institution which stands for all that is best in educational progress. The splendid facilities provided for the comfort, pleasure, and convenience of the Association contributed in no small measure to make this one of the most successful meetings.

The general sessions were held in Mandel Hall. After an organ prelude by Mr. Stevens, the Association was welcomed by Dr. Roland D. Salisbury of the University. Prof. Marquis J. Newell of Evanston High School replied on behalf of the Association. The two principal addresses of the morning session were given by Dr. David Snedden, Professor of Educational Sociology, Columbia University, and Dr. John F. Hayford, Director of the College of Engineering, Northwestern University. Dr. Snedden gave an inspiring address on "The High School of Tomorrow." Dr. Hayford's address, illustrated by official lantern slides, showed the real facts concerning the great landslides of the Panama Canal and the effective methods employed by the government in controlling them. It is to be regretted that the lecture cannot be given in full in the *Proceedings*, the government forbidding its publication at this time.

Friday afternoon was occupied with section meetings, inspection of exhibits, and an informal reception in the parlors of the Ida Noyes Hall. At 6 p. m. a large and enthusiastic number of members gathered for dinner in the dining hall of this building. The dinner was followed by an informal discussion of the main topic, "The High School of Tomorrow." Principal Johnson of the University High School opened this discussion by an address dealing mainly with the administrative side of the subject. This was followed by a most interesting and animated general discussion, in which different phases of the subject were considered. It appeared that all were not converts to Dr. Snedden's idea of what the future schools should or would be. It was evident, however, that he made a deep impression, and it was generally felt that there must be a frank and thorough investigation of educational problems. Franklin T. Jones of Cleveland, Ohio, offered a resolution, "That the chairman of this meeting, Herbert R. Smith, President of the Association, appoint a committee of six to prepare and present to the Association a course in science and mathematics for the 'High School of Tomorrow.'"

The general session of Saturday morning was devoted to business, followed by a continuation of the section programs. The minutes of the 1915 meeting were read and approved.

The Auditing Committee reported that they had found the Treasurer's accounts correct. The Treasurer then read his report, and both reports were adopted. The Treasurer also announced that 320 new members had been received into the Association during the past year.

It was moved and seconded that the Treasurer's remuneration be increased from \$25 to \$50 per annum. Carried.

It was moved and seconded that the Treasurer for 1913 and 1914, Herbert R. Smith, be paid \$25 for services. The President ruled the motion out of order.

Frank B. Wade, chairman of the Committee on Resolutions, presented the following resolutions, which were read and adopted:



"1. Resolved, That the Central Association extend its hearty thanks to the University and its officers for the splendid facilities provided for the general and section meetings of the Association, and especially for the generous and hospitable entertainment furnished us in the beautiful Ida Noyes Hall.

"2. Resolved, That the Central Association extend its thanks and appreciation to Dr. David Snedden for his interest, as evidenced by his willingness to make a long trip to bring to us so stimulating an address.

"3. Resolved, That the Central Association voice its appreciation of the interest of Prof. John F. Hayford, shown by his giving us his instructive illustrated lecture on the Panama slides.

"4. Resolved, That the Central Association especially extend its thanks to Mrs. Goodspeed and Miss Colburn for their courtesies to the Association in connection with the reception and dinner in the Ida Noyes Hall.

"5. Resolved, That the Central Association extend its hearty thanks to the following members who have faithfully attended to especially arduous duties in connection with the meetings of the Association: A. M. Allison, Chairman of the Membership Committee; H. B. Shinn, Chairman of the Advertising Committee; J. H. McClellan, Treasurer; Raleigh Schorling, Chairman of Committee on Arrangements.

"6. Resolved, That the Central Association consider as the principal theme for next year's program, 'The Formulation of the Immediate and Ultimate Aims of Science and Mathematics Teaching.'

The Membership Committee report was read by its Chairman, A. M. Allison. The report was approved and ordered filed. A vote of thanks was extended to the committee for their excellent work in securing new members to the Association.

The Nominating Committee reported the following:

President—E. Marie Gule, Columbus, Ohio.

Vice-President—Harry D. Abells, Morgan Park, Ill.

Secretary—A. W. Cavanaugh, Lewis Institute, Chicago, Ill.

Treasurer—John H. McClellan, Harrison Technical High School, Chicago, Ill.

Corresponding Secretary—Allan Peterson, East High School, Des Moines, Iowa.

Assistant Treasurer—Evan L. Mahaffy, Columbus, Ohio.

HERBERT E. COBB. FRANKLIN T. JONES. JESSIE CAPLIN.

The Secretary was ordered to cast a white ballot for the persons nominated, and they were duly declared elected.

The Secretary was instructed to express the sympathy of the Association to Prof. James F. Millis in his severe illness.

Invitations to hold the next annual meeting of the Association were received from Columbus, Ohio, Cincinnati, Ohio, Grand Rapids, Mich., St. Louis, Mo., Brockport, N. Y., and Norfolk, Va. On motion, the Association expressed its appreciation of these invitations, and by vote decided to hold the 1917 meeting in Columbus, Ohio.

A. W. CAVANAUGH,  
Secretary.

#### TREASURER'S REPORT FOR YEAR ENDING DECEMBER 1, 1916.

##### *Receipts.*

Balance, at previous report.....	\$ 499.52
Tickets sold for annual dinner.....	81.60
Twelve copies <i>Proceedings</i> .....	6.00

Advertisements in 1915 program.....	\$ 218.00
Advertisements in 1916 program.....	74.00
Membership dues at \$2.50.....	1,920.00
Membership dues, irregular .....	158.35

Total receipts .....\$2,957.47

*Expenditures*

Subscriptions to SCHOOL SCIENCE AND MATHEMATICS.....	\$1,088.50
Subscriptions to <i>American Journal of Home Economics</i> .....	130.50
<i>Proceedings</i> , 1915, printing and distributing.....	351.32
Program, 1915, printing and distributing.....	229.96
Program, 1916, postage.....	110.00
Rebates to local centers.....	27.00
Rebate to member on account of error.....	.50
Miscellaneous:	
Agriculture Section expense .....	\$ 3.00
Biology Section expense .....	11.00
Earth Science Section expense.....	4.75
Home Economics Section expense.....	5.78
Mathematics Section expense .....	6.00
Physics Section expense .....	4.00
Convention speakers .....	95.59
President's expense .....	10.10
Membership Committee expense .....	109.03
Secretary's expense .....	7.50
Treasurer's expense .....	51.85
Treasurer's bond .....	2.50
Chemistry survey .....	21.71
Publicity Committee expense .....	2.65
Advertising Committee expense .....	2.80
Four-Year Science Committee expense.....	41.00
Present Status of Physiography Committee expense....	5.00
Printing and stationery .....	38.98
Home Economics refunds .....	12.00
Home Economics membership expense.....	20.00
Badges, 1916 .....	12.60
138 dinners at fifty cents.....	69.00
<i>Proceedings</i> expense .....	1.90
Balance .....	538.74
	480.95

\$2,957.47

*Membership Report for the Year Ending December 1, 1916.*

Paid-up membership, November 26, 1915.....	768
Honorary membership .....	9
Total membership .....	777
Delinquent, but left on the list as per Constitution.....	95
Total names remaining on list, December 1, 1916.....	872
New names added during year.....	320
Total .....	1,192
Resigned during the year.....	67
Deceased or dropped for delinquency.....	57
	124
Net Constitutional membership, December 1, 1916.....	1,068

## MINUTES OF THE MEETING OF THE AGRICULTURAL SECTION.

H. N. Goddard, State High School Inspector of Wisconsin and Chairman of this section, called the meeting to order. The permanent Secretary being absent, Winfield Scott, Assistant in Agriculture in the Illinois State Normal School, was appointed Secretary.

Dr. L. H. Pammell, Professor of Botany, Iowa State College, read a paper on "Organization of the High School Sciences in Relation to the Four-Year Course in Agriculture."

Prof. Albert Vivian, Dean of the College of Agriculture, Columbus, Ohio, gave a talk on "Aims and Values of Agriculture in the High School."

The section adjourned until 10 a. m., December 2.

The Agricultural Section met on December 2, at 10 a. m., and a Round Table conference was led by Prof. Z. M. Smith, State Inspector of Agriculture of Indiana. "Laboratory Work in the High School" was the subject which received chief consideration.

C. H. Lane, Chief Specialist in Agricultural Education, U. S. A. Department of Agriculture, because of delayed train service, arrived late and most of his paper on "Aims and Methods of Project Work in Secondary Schools," was omitted.

H. N. Goddard was reelected Chairman, G. E. Wilson of Platteville, Wis., Vice-Chairman, and Charles H. Keltner, De Kalb, Ill., Secretary.

A motion was carried to leave the future of the Agricultural Section to H. N. Goddard and C. H. Lane.

The section adjourned to meet at the call of the committee named above.

WINFIELD SCOTT,  
*Secretary pro tem.*

## MINUTES OF THE BIOLOGY SECTION.

The Biology Section of the Central Association of Science and Mathematics Teachers met at 1 p. m., Friday, December 1, in Room 13, Botany Building, of the University of Chicago. Fred T. Ullrich, Platteville Normal School, Platteville, Wis., presided. The Chairman appointed as the Nominating Committee the following persons: F. C. Lucas, Chicago; Evan L. Mahaffey, Columbus, Ohio; O. D. Frank, Quincy, Ill.

The Chairman explained that letters were sent to all members at the beginning of the year, asking for suggestions for the program. The committee was especially grateful for the suggestions received, and the program was based entirely upon these suggestions.

A paper, "Some Recent Advances in Plant Pathology," by L. R. Jones, Professor of Plant Pathology, University of Wisconsin, presented some practical methods in the conservation of human effort in growing potatoes and cabbages.

J. M. Coulter, Professor and Head of the Department of Botany, University of Chicago, discussed his most recent ideas on the subject, "Inheritance and Response."

Since many of the states are requiring that agriculture be taught in the schools, there has arisen a great interest in the minds of the people teaching botany as to the relation that botany shall have toward the courses in agriculture. For this reason, L. H. Pammel, Professor of Botany, Iowa State College of Agriculture and Mechanic Arts, Ames, was called upon to discuss the subject, "The Organization of a Course in Botany in the High School as a Preparation for Subsequent Courses in Agriculture."

L. E. Hildebrand, Kennilworth, Ill., raised the point that most of our botany textbooks were written primarily for city schools, the probable reason for this being that publishers wished to make good sellers, and as most of the trade was with city schools, they catered to the city trade. Mr. Hildebrand maintained that the country schools should have a different type of botany, one dealing more particularly with practical phases, and one which would call for more out-of-door work. Mr. Hildebrand also said that some of the blame for the present-day teaching was largely due to the fact that colleges did not train teachers to teach practical botany in high schools.

Prof. T. W. Galloway, Beloit College, Wis., said he thought the section owed Prof. Jones of the University of Wisconsin a vote of thanks for giving such a practical demonstration of college botany. Prof. Galloway acknowledged that the high school teachers were not so much to blame for the type of botany they taught, as was the average university professor who viewed each student as a prospective graduate from his department. He said we should hope for another type of ambition in our college professors. He further said that some of the greatest thrills to be obtained in the work were discovering with some pupil a rare plant, or some interesting new fact in the field of botany. The real inspiration of teaching should be found, not in turning out so many graduate students from the department, but in making the science a living, vital force in the life of the student.

Mr. Ullrich said that of the fourteen courses in botany which he had taken in the colleges, he had found very little material to be used in his teaching work, yet he felt that these same courses had given him a background from which he could work out his material in high schools to much better advantage.

Prof. C. J. Chamberlain, University of Chicago, related a little story often told by Prof. Barnes which illustrated the fact that most college graduates administer in teaching a vast amount of information which they themselves have not been able to digest and assimilate.

Prof. Clute asked if the university had not been able to note results in students entering college which would show that the teaching in high schools had not been altogether bad.

Dr. Otis Caldwell stated that this matter had already been investigated, and the report showed that the greater majority of students who ranked highest in their botany work had received some previous training in botany in high school.

Prof. E. M. Gilbert, University of Wisconsin, stated that his university had also made such an investigation with results similar to those obtained by Dr. Caldwell in the University of Chicago.

The question was again raised by Dr. Caldwell as to whether it was advisable to make a distinction between material for the city and for the country. He said botany was one of the *life sciences*. To be dynamic it must be regulated by exercises the student may have coming into his experience later. He cited a case of a student who was advised not to take botany. This student persisted that he wanted to take botany, and finally took a course under him. One day this student surprised him greatly by handing in a very valuable treatise on the subject of trees. This was an expression of the student's early interest gained under some high school teacher. He said home interests should furnish a vast amount of material. This serves to intellectualize one's surroundings through the study of botany. Dr. Caldwell further suggested that teachers look upon books as laboratory equipment.

Mr. Whitney, Hyde Park High School, said that carrying out Mr. Sneddon's statement in the morning "That the subject of botany was not yet crystallized," and "That there should be two phases in teaching, a vocational and the appreciative," he felt that we should put biology more on the appreciation side. He said we might teach biology for citizenship, for pure agriculture, and for culture.

A report of the Survey Committee for Biology, appointed by the Illinois Conference, was presented by Harold Shinn of the Carl Schurz High School, Chicago. He stated that a set of outline studies in botany, zoology, and physiology were sent to each school in the state. Replies were received from a large number of the schools. A minority showed a tendency to depart from the stipulated outline of work, and about forty schools accepted the report as it stood, or, in other words, swallowed hook, bait, and all. It was urged that all go over these outlines again, make comments on subjects as presented in the courses, and turn over these comments to the committee.

The report was laid on the table.

As an early report of the Nominating Committee was called for by the Executive Committee, the following report was presented:

Chairman—Nettie M. Cook, Springfield, Ill.

Vice-Chairman—J. M. Robinson, Columbus, Ohio.

Secretary—I. M. Isanbarger, Chicago, Ill.

This report was accepted.

The Saturday morning meeting at 10 a. m. opened with the reading of the minutes of the last meeting by the Secretary.

The main feature of the morning's program was a symposium on the subject, "A First Course in Zoology in the High School." The "Aims" of such a course were outlined by Prof. T. W. Galloway, Beloit College, Beloit, Wis. As Prof. Galloway was unable to attend the meeting, the paper was read by John G. Coulter, Bloomington, Ill. "The Content and Organization" of such a course was discussed by Jerome Isenbarger, Nicholas Senn High School, Chicago. "Available Texts" was presented by Dr. Elliott R. Downing, School of Education, University of Chicago. This paper was read by O. D. Frank, Quincy High School.

A brief discussion followed. Mr. Hildebrand complimented Mr. Isenbarger on his live presentation of his subject. It was requested that Miss Helen Loomis, Bowen High School, Chicago, tell about her experiences in conducting a small fish hatchery in the laboratory. She stated that she had already written them out for the December issue of *SCHOOL SCIENCE AND MATHEMATICS*.

The morning's program was concluded by a thoroughly live discussion on "How School Gardens Tend to Direct a Natural Course in Botany," by Genevieve Monsch, Froebel High School, Gary, Ind.

The meeting adjourned to take a trip with Dr. Otis Caldwell, University of Chicago, to the Field Museum of Natural History.

NETTIE M. COOK,  
Secretary.

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#### MINUTES OF EARTH SCIENCE SECTION.

The meeting was called to order by the Chairman, Miss Marion Sykes.

The Chair then appointed the members of the Nominating Committee as follows: C. S. Winslow, Nicholas Senn High School, Chairman; C. E. Peet, Lewis Institute; Meta C. Mannhardt, Evanston Township High School.



A committee of three, to formulate the policy for this section at the meeting next year, was to be appointed later. This committee was to have the resolutions ready for the Executive Committee.

A larger committee of fifteen was to be appointed to assist C. H. Smith in the work on the recommendation to improve railroad maps. This committee was to confer in the matter with Congressman Mann.

The following program was submitted:

"Vocational Aspects of the Earth Sciences"—Rollin D. Salisbury, University of Chicago.

"Geological Sciences as Adapted to the Development of Mineral Resources (with Special Reference to Illinois)"—Frank W. De Wolf, Director of State Geological Survey, Urbana, Ill.

"Some Experiences in Schools Where the Junior-Senior High School Is in Operation."

(a) "Geography and General Science in the Decatur, Ill., High School"—Stanislaus Arseneau, Harvard School, Chicago.

(b) "Difficulties in Organizing the Science Work in the Junior High School"—D. G. Mac Millan, Central High School, Grand Rapids, Mich.

(c) "Geography in the Schools of Columbus"—Evan Mahaffey, High School of Commerce, Columbus, Ohio.

Charles Winslow gave the report of the committee appointed in November, 1915, on the work of the reorganized high school.

*Report of the Committee on Earth Science in the Reorganized (Junior-Senior) High School.*

An unusual opportunity is afforded us of readjusting courses of study, revising contents, and of improving methods. All of these are expected when the reorganization of a school takes place. Today we stand at the beginning of a movement for fundamental changes in the organization of our high schools and of the schools that articulate with them—the elementary school below, and the college above.

Probably no fundamental branch of learning is so much in need of a renaissance as is the science of geography in its various forms. There can be no defense of a high school course that leaves its graduates grossly ignorant of the countries, and peoples, and cities, and industries of the world with which their lives are vitally connected. No education can profess to be balanced whose pupils are ignorant of the geographical aspects of the earth and its inhabitants. It would be difficult to exaggerate the *ignorance* of our graduates in this respect. There is absolutely no defense of such a condition. The situation has become intolerable. The reorganization of our schools into junior-senior high schools offers an unparalleled opportunity for the introduction of work that will revive this subject in its various phases. This Association and others similar to it will not have discharged their duty to our schools until they shall have made known their findings, and aroused the cooperative interest of the administrators of our schools, and also of the teachers, the parents, the boards of education, and the students themselves. Especially must we gain the attention of those in our normal schools and colleges who arrange the courses of study for persons who are to teach. In the hope of contributing toward this end, your committee respectfully submits a tentative outline of courses of geography for your discussion, criticism, and action. The committee realizes that further work should be done in rearranging to some extent the work in the elementary school, so as to make it culminate in the high school; and in conferring with higher institutions so as to make our work lead up to and become a substantial foundation for advanced training along these lines.

In the outline herewith presented, the committee has refrained from giving details; it has given only the broad divisions. After discussion and modification by the section, if the outline meets with favor it should be recast and amplified by subdivision and expansion of the topics approved.

Respectfully submitted,

JAMES H. SMITH, *Chairman*,  
FRANCES ABBOTT,  
META MANNHARDT,  
W. R. MCCONNELL,

MARION SYKES,  
R. S. WHITLOCK,  
CHARLES S. WINSLOW,  
*Committee*,

*Proposed Geography Courses for the Reorganized (Junior-Senior) High School.*

Seventh Grade—Required in all courses.

Fundamental Political and Physical Geography.

Climatic Belts and Regions of the Earth.

The Continents.

Principal Mountains.

Principal Plateaus.

Principal Rivers.

The Oceans.

Principal Harbors and Ports.

Principal Commercial Products.

Principal Cities.

Eighth Grade—Required in all courses.

Regional Geography of the United States (one-half year).

General Science (one-half year).

Ninth Grade—Required in all courses.

Physiography, including Regional Geography of the Earth (one year).

Tenth Grade—Required in all vocational, industrial, commercial, and technical courses, including cooking and sewing courses, elective in other courses.

Industrial and Commercial Geography.

Eleventh and Twelfth Grades—Required in all normal and teachers' courses; elective in other courses.

Applied Geography of the World based upon Climatic Regions (one year).

A motion was made and seconded to have the work of the committee continued, as the suggestions as outlined so far were not yet fully developed.

Miss Baber, University of Chicago: "What does applied geography mean?"

Mr. Winslow: "Study of typical regions in application to human industries."

Mr. Andrews, Pana Township High School, on the committee working on a course for tenth-grade geography: "There was a difference of opinion on what should be the basic ideas underlying the first part of their course, but it was generally assumed that a ninth-grade course in physiography, like that in Salisbury's *Briefer Course*, should precede the tenth-grade work. Then the work should proceed into *human* geography, rather than into *applied* geography."

Miss Annie S. Weller, Charleston Normal School: "The outline being prepared by the Geography Section of a high school conference suggested the study of typical climatic regions first, then surface and shore-line types; each to be followed by the study of similar regions and final application to the home country."

Mr. Arseneau brought up discussion of contents of a general science course. He thought that the general science should be a course in itself and should be followed by physiography.

Miss Sykes: "If the geography situation continues as it is now, it will be the fault of the teachers themselves if geography is crowded out altogether. If the teachers of geography do not see to it, the subject will be left out of the program of the reorganized high school altogether."

Mr. Andrews: "Geography is being neglected in the high school. Other sciences will secure the entire program if we are not careful. A tremendous business interest is trying to crowd out geography, viz., general science. We ought to enthuse on geography, to advocate sharply on the staff on which we teach that geography offers the richest content for the adolescent mind. The glory of our subject lies in the fact that it arouses interest in travel, acquaints with the countries of the world, and makes the children feel their relationship to all the world."

Miss Baber: "The content of geography is most stimulating and remunerative to the human mind. It makes us live with other people better. The adolescent child comes in contact with all the people of the world in geography."

Dr. Dryer stated that the course as outlined pleased him very much, but he feared that it would never be given room on the program. He asked Prof. Salisbury why it is so difficult to get teachers of geography.

Prof. Salisbury: "The fault lies in the public attitude. When students know enough they want to teach in a college. They do not realize that if they are adapted to teach in the grades or in the high school, that that is their place and not in the college."

Miss Baber said the students coming to them had had no geography since the seventh grade.

Mr. Wood of Senn: "The usual fault of outlines is that *subjects* are outlined on a *scientific basis*, without reference to the *pupil* or the *change in the pupil*. Will the committee present an outline in the interest of the student's life or according to the subject?" He asked the committee to present a suggestive outline.

Prof. Salisbury: "We need teachers who are really interested."

Mr. Peet: "Eighth-grade general science is a necessary basis for physiography. The need is for better prepared teachers. The outlined program will send people to normal school better prepared, and therefore will result in better grade teachers. The ultimate result will be in favor of the high school."

The following Committee on Resolutions was appointed: Mr. Peet, Mr. Wood and Mr. Andrews.

The meeting was adjourned.

The meeting was called to order on December 2, by Miss Sykes.

The Nominating Committee reported, and the following officers were elected for next year:

Chairman—W. R. McConnell, Normal School, Platteville, Wis.

Vice-Chairman—George D. Hubbard, Oberlin College, Ohio.

Secretary—Mabel Stark, Illinois State Normal University, Normal, Ill.

The following Committee on Railroad Maps was appointed: Dr. J. Paul Goode, University of Chicago; C. E. Peet, Lewis Institute; C. H. Smith, Hyde Park High School.

The new officers were installed.

The meeting was turned over to Miss Stark in the interests of the Illinois Council of Geography Teachers.

The following program was submitted:

"The Scope and Method of High School Geography"—Charles R. Dryer, Fort Wayne, Ind.

"Geography and Boys"—Robert G. Buzzard, formerly of Harvard School for Boys, Chicago.

Discussion: "Earth Sciences in the Elementary and High Schools of Tomorrow."

Miss Weller, Charleston Normal School: "Need for more work in geography in the high school, and a different kind of work. Students now come, disliking the subject. Could do better in the normal school if better prepared. This would result in better work in the grades."

Miss Southworth, De Kalb Normal: "A course of study for the training school ought to show a progress in methods of teaching as well as in selection of subject matter. We need to interest the grade teachers."

Mr. Jay of Macomb Normal: "Ordinary fact geography is not even that. There is a general lack of source of material. The geography work should have its basis on human interests."

Mr. Bassett, Western Normal: "The pessimism over the geography situation is misplaced. The growth of geography departments in the universities is bound to spread the gospel of the richest subject in the curriculum."

Mr. Andrews: "The executives must be interested. The good work done by the pupils will bring out the advantages of the subject."

Mr. Gould, Milwaukee Normal School: "The psychological approach is from the concrete problem. Nine-tenths of the pupils cannot work from cause to effect."

Dr. Goode: "Schools of France offer best work in geography. Necessary to begin at the top to regenerate the work in the lower schools. Geography to be taught with current history."

Mr. Peet read the following resolutions:

"1. This section wishes to place on record its approval of the plan reported by the committee yesterday, of placing the geography of the high school on a physiographic basis and of basing the work in physiography on a knowledge of the underlying physical sciences. We would raise the question whether the experience of those who have worked in this field in the seventh and eighth grades does not justify this rise to a level higher than that of the grammar school geography earlier in the junior high school than the ninth grade.

"2. We would voice our approval of the emphasis laid in that report on the need of an extended course in geography for those who are to teach the subject in the grammar grades. Until the preparation of the teacher of geography in the grammar grades is more adequate, the burden on the high school will remain a heavy one.

"3. It is our belief that too great emphasis cannot be placed upon the need of adequate preparation of the high school instructor, which should be the equal in the junior high school of that in the senior high school, and should include not only preparation in subject matter but also professional training as a teacher. For, after all, success in teaching in the high school depends primarily on the ability of the instructor to see things from the point of view of youth, and requires teachers of broad sympathy and wide outlook, a knowledge of the student as well as a knowledge of subject matter.

"4. It is our belief that the future of geography in the high school depends on the teacher. If it is to expand or even hold its own, it must produce results. The business must be built up through satisfied customers. The teacher cannot expect the administration to capture the

student and hold him down, while he administers the dose. At no time in the history of the world have the facilities for teaching geography, and the possibilities for making it fascinating to the young student, been so great. The world is at our doors, the automobile, the electric car, and the suburban train with low fares invite to the fields. With the moving picture, the lantern slide, and the traveling museum, the world can be brought into the schoolroom.

It is our belief that the means mentioned to make the study of the subject attractive are too commonly and sadly neglected.

It is further our belief that not only is there failure to take advantage of local features to vitalize the study, but that the opportunity for exchange of information between students and between teachers of geography is another possible source for stimulating interest which is almost wholly neglected.

"5. The greatest need of today is a clear definition of the prevocational mission of the public high school. It is conceded that the elementary schools stand for the education which is essential for all, that the university undertakes the special education of those who have chosen their life work.

"The high school must assume responsibility for the larger number who choose their life work while in the high school, and who do not propose to avail themselves of university training.

"The need is great for a formulation of the basic ideas and working plans for (1) promoting higher administrative efficiency toward the above ends in the executive department of the high schools, and (2) promoting higher departmental insight and sagacity among the teachers in furthering this definite mission of the public high school."

Upon motion duly made and seconded, the meeting was declared adjourned by the Chairman, Miss Sykes.

META C. MANNHARDT,  
*Secretary.*

### ECONOMY IN SCIENCE.

The increased extent to which the large industrial corporations of the country now support their own departments of scientific research is a gratifying development of the times. Science is regarded as a necessity rather than a luxury. And this coming of science into its own as a large factor in the industrial life of the nation is necessarily followed by a certain reaction of business upon science. Never before, perhaps, has the demand been so keen for research that is no less than ever scientific in spirit and in method, but that has a definite purpose and yields definite results. The idea of making science useful is not new, but the utility of science has become more universally the test of its value.

In the scientific work done under the Federal Government, this demand for results is abundantly justified by the public need. If the strongest corporations are making large use of chemists, physicists, and geologists, the general public has similar need in its service for applied science.

The business policy of organizing scientific investigation for effective work, however, is far from novel, for in 1878, in the report to Congress advocating the creation of the United States Geological Survey, the National Academy of Sciences described the ideal plan for a scientific bureau as that which would yield the "best results at the least possible cost." Since that day, moreover, economy in science has become a more pressing issue.—[37th Ann. Report, Director U. S. Geological Survey, Department of the Interior.



**PROBLEM DEPARTMENT.**

Conducted by J. O. Hassler,

Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider accuracy, completeness, and brevity as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

**Algebra.**

491. Proposed by Harry M. Roeser, Washington, D. C.

Solve:

$$\begin{aligned}x^2+x &= y^2+y, \\x^2+x^2 &= y^2+y.\end{aligned}$$

Solution by R. M. Mathews, Riverside, Cal.

These two equations give

$$\begin{aligned}x(x+1) &= y(y^2+1), \\x^2(x+1) &= y(y^2+1),\end{aligned}$$

and are satisfied by the solutions of the several equations.

$$\left. \begin{aligned}x^2 &= 0, \\y &= 0,\end{aligned} \right\} \text{ Solutions } (0, 0) \quad (0, 0).$$

$$\left. \begin{aligned}x+1 &= 0, \\y &= 0,\end{aligned} \right\} \text{ Solution } (-1, 0).$$

$$x = \frac{y^2+1}{y^2+1},$$

$$x(x+1) = y(y^2+1).$$

From this last equation,

$$(y^2+1)(y^3+y^2+2) = y(y^2+1)^2,$$

whence

$$(y^2-1)(y^2-y+2) = 0,$$

and

$$y = \frac{1 \pm \sqrt{-7}}{2}, \quad x = \frac{-1 \pm \sqrt{-7}}{2},$$

$$y = 1, \quad x = 1,$$

$$y = \omega, \quad x = \frac{\omega^2+1}{\omega^2+1},$$

$$y = \omega^2, \quad x = \frac{\omega+1}{\omega^2+1},$$

$$y = \omega^3, \quad x = \frac{\omega^4+1}{\omega+1}$$

$$y = \omega^4, x = \frac{\omega^3 + 1}{\omega^2 + 1},$$

where  $\omega^5 = 1$ .

This gives ten of the twelve solutions. It will be observed that in the solution of the last system two cubics are solved simultaneously, so that there should be an equation of the ninth degree in  $y$ , whereas it is of the seventh. Possibly the other two are infinite.

492. *Proposed by Harry M. Roeser, Washington, D. C.*

The popular game, "shooting craps," is played as follows:

Two players place a stake. "A" throws two dice. If the sum of the spots turned up at the first throw totals 7 or 11, he wins; if they total 2, 3 or 12, he loses. If none of these points are turned, he throws again and again and wins when he duplicates the point that is turned on the first throw. He loses if, while attempting to duplicate his point, the dice turn up 7. Let it be required to demonstrate that the player rolling the dice has or has not an even chance of winning.

There were no correct solutions received for this problem. Its solution presents some interesting details, and the Editor feels that many of the contributors might find pleasure and profit in the excursion into the theory of chance presented by the problem. It will be repeated.—Editor.

### Geometry.

493. *Proposed by Norman Anning, Chilliwack, B. C.*

An antiquarian finds a brick, 8 inches long, 2 inches thick at one end, and  $1\frac{1}{4}$  inches at the other, and covered uniformly with mortar  $\frac{1}{4}$  inch thick. He reasons that it formed part of a semicircular arch. Find the span and number of bricks.

I. *Solution by Nelson L. Roray, Metuchen, N. J.*

The dimensions of the brick in the arch are: 2.25 inches at one end, 2 inches at the other, and 8 inches long. Then 2.25 inches is the chord of a circle whose radius is  $x+8$ , and 2 inches is the chord of a circle concentric with the first, whose radius is  $x$ .

Hence,

$$1.125 : 8+x = 1 : x,$$

whence

$$x = 64,$$

and radius of space is 72 inches.

The central angle of a chord of 2.25 inches in a circle whose radius is 72 inches is easily shown to be about 107.3 minutes.

$$\therefore 10,800 \div 107.3 = 100 \quad (\text{number of bricks in arch}).$$

II. *Solution by C. E. Githens, Wheeling, W. Va.*

Let AB and AF be the respective distances from the upper end and the lower end of a brick to the center of the semicircular arch of which the upper edges of the bricks and the lower edges of the same form approximately two semicircumferences.

Let BD and EF equal one-half the thicknesses, respectively, of the upper and lower end of a brick, plus one-fourth inch for mortar for each brick. BD = 1.25 inches, FE = 1.125 inches, surface = 20.1875 square inches.

Then

$$\frac{\text{The surface of the arch}}{\text{Surface of a brick}} = \text{number of bricks.}$$

By proportion of similar triangles, AB = 85 inches, AF = 76.5 inches.

$$\frac{\pi}{2} \left( \frac{(85^2 + 1.25^2) - (76.5^2 + 1.125^2)}{20.1875} \right) = 107 \text{ bricks.}$$

The span =  $2 \times 85$  inches = 14 ft., 2 in.

[It will be noticed that the two solvers placed different interpretations on the statement, "covered uniformly with mortar one-fourth inch thick."—Editor.]

494. Proposed by R. T. McGregor, Bangor, Cal.

AB and CD are two parallel chords of a circle, and L and M are their mid-points, respectively. BM and DL are produced to meet the circle again in E and F. Prove that the five following points are collinear: the points of intersection of BM and DL, of BC and DA, of FC and EA, of the tangents at A and C, of the tangents at B and D.

Solution by Nelson L. Koray, Metuchen, N. J.

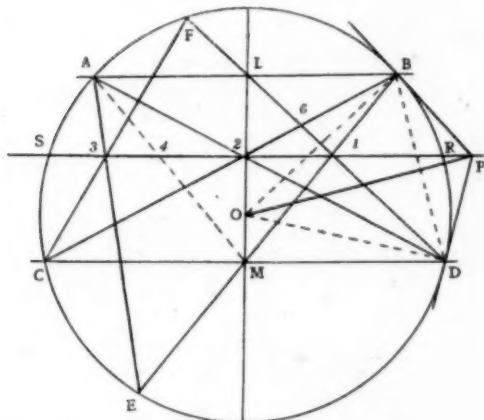
$$\text{From the trapezoid LBDM, } \frac{D1}{1L} = \frac{2\overline{MD}}{2\overline{LB}}.$$

$$\text{From the trapezoid ABDC, } \frac{D2}{2A} = \frac{CD}{AB}.$$

$$\therefore \frac{D1}{1L} = \frac{D2}{2A} \text{ and } 12 \parallel AB.$$

In the  $\triangle AEM$  cut by transversal 13, we have

$$\frac{A3}{3E} \cdot \frac{E1}{M1} \cdot \frac{M4}{4A} = 1 \cdot (A)$$



In the  $\triangle BCM$  cut by transversal FD, we have

$$\frac{B1}{1M} \cdot \frac{MD}{CD} \cdot \frac{C6}{B6} = 1 \cdot (B)$$

Simplifying  $A \times 1$ , we get  $\frac{A3}{B} \cdot \frac{E1}{3E} \cdot \frac{E1}{B1} = 1$ , and  $13 \parallel AB$ .

$\therefore 1, 2$ , and  $3$  are collinear.

$$\angle B2D = \angle BOD \text{ (both meas. by } \widehat{BD}).$$

$\therefore B, 2, O, D$  are concyclic,

$$\text{and } \angle 2BO = \angle 2PO,$$

$$\angle OBD = \angle OPD.$$

$$\therefore \angle 2BD = \angle 2PD,$$

$$\text{and } \frac{1}{2} \widehat{CED} = \frac{1}{2} (\widehat{SC} + \widehat{CED} - \widehat{RD}).$$

$$\therefore \widehat{SC} = \widehat{RD} \text{ and } P2 \parallel AB.$$

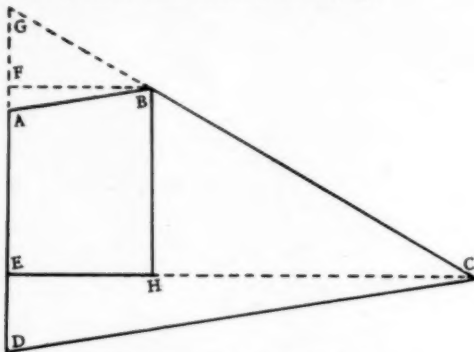
In same manner, prove  $P'2 \parallel AB$ ,  $P'$  intersection of tangents at A and C.

$\therefore P, 1, 2, 3$  and  $P'$  are collinear.

495. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

The sides of a trapezoid in order are 3, 5, 10 and 8, respectively, the sides that are parallel being 3 and 10. Find the volume generated by revolving the trapezoid about side 5.

1. *Solution by J. W. Ogg, Glendale, Ariz. Essentially the same solution by De Witt T. Weaver and Nelson L. Roray.*



Let ABCD be the given trapezoid with its sides 3, 8, 10 and 5 units, respectively. Let AB be parallel to CD.

*Required:* The volume of the solid generated if ABCD be revolved around AD as an axis.

Produce CB and DA until they intersect at G. Drop perpendiculars from C and B to DG, meeting it at the points E and F, respectively. Draw BH parallel to FE.

Let line ED equal  $x$ . Then  $EC = \sqrt{100 - x^2}$ .

From the similar triangles ABF and DCE (sides respectively parallel), we find  $FB = \frac{3}{10}\sqrt{100 - x^2}$  and  $AF = \frac{3}{10}x$ .

Now  $AE = 5 - x$  and  $FE = 5 - \frac{7}{10}x$ .

$\therefore BH = 5 - \frac{7}{10}x$  and  $EH = FB = \frac{3}{10}\sqrt{100 - x^2}$ .  $HC = \frac{7}{10}\sqrt{100 - x^2}$ .  
 $(5 - \frac{7}{10}x)^2 + (\frac{7}{10}\sqrt{100 - x^2})^2 = 8^2$ . (rt.  $\Delta$  BHC.)

Solving:

$$x = \frac{10}{7}.$$

Substituting,

$$ED = \frac{10}{7}, \quad EC = \frac{40}{7}\sqrt{3}, \quad FB = \frac{12}{7}\sqrt{3}, \quad AF = \frac{3}{7}, \quad FE = 4.$$

By similar triangles FBG and ECG,  $FG = \frac{15}{7}$ ,  $AG = 2\frac{1}{7}$ , and  $DG = 7\frac{1}{7}$ .

The solid required is equal to the solid formed by revolving the triangle DCG about DG, less the solid generated by revolving the triangle ABG about AG, or

$$\begin{aligned} & \frac{1}{3} \cdot \pi \cdot 7\frac{1}{7} \cdot \left(\frac{40}{7}\sqrt{3}\right)^2 - \frac{1}{3} \cdot \pi \cdot 2\frac{1}{7} \cdot \left(\frac{12}{7}\sqrt{3}\right)^2 \\ &= \frac{77,840 \cdot \pi}{7^3} = 712.95 \dots \text{cubic units.} \end{aligned}$$

II. *Solution by R. T. McGregor, Nord, Cal.*

The centroid of the trapezoid is found to be  $\frac{460}{273}\sqrt{3}$  from side 3, and

the perpendicular from the centroid to side 5 is  $\frac{556}{273}\sqrt{3}$ . The area of the

trapezoid is  $\frac{130}{7}\sqrt{3}$ . Hence, the volume generated by revolving the trapezoid about side 5, by the theorem of Pappus, is

$$\frac{130\sqrt{3} \cdot 2\pi \cdot 556\sqrt{3}}{7 \cdot 273} = \frac{11120\pi}{49}$$

**CREDIT FOR SOLUTIONS.**

486. Myra J. Hawes. (1)  
 487. One incorrect solution. (1)  
 491. Norman Anning, R. M. Mathews, Nelson L. Roray, five incorrect and incomplete solutions. (8)  
 492. One incorrect solution. (1)  
 493. C. E. Githens, Arthur B. Hussey, Nelson L. Roray, one incorrect solution. (4)  
 494. Nelson L. Roray. (1)  
 495. Norman Anning (2), Felix S. Hales, R. M. Mathews, R. T. McGregor, J. W. Ogg, Nelson L. Roray, Dewitt T. Weaver, one incorrect solution. (9)  
 25 solutions.

**PROBLEMS FOR SOLUTION.**

**Algebra.**

492. This problem repeated. See page 172.  
 506. *Selected.*

There is some coal on a dock, and coal is running on the dock through a chute at a uniform rate. Six men can clear the dock in one hour, or eleven men can clear it in twenty minutes. How long will it take four men to clear the dock?

**Geometry.**

507. *Proposed by C. E. Githens, Wheeling, W. Va.*  
 Given the center and radius of a circle, to find the side of the regular inscribed pentagon by means of the compass alone.  
 508. *Proposed by R. G. Rupp, Hammond, Ind.*  
 Through a given point P, within a given circle draw a chord AB, so that the ratio AP:PB shall be equal to a given ratio  $m:n$ .  
 509. *Proposed by R. T. McGregor, Nord, Cal.*

TP and TQ are any two tangents, and TRS any chord of a circle. If V is the mid-point of RS, and QV meets the circle again in P', prove that PP' is parallel to ST.

**Trigonometry.**

510. *Proposed by Norman Anning, Chilliwick, B. C.*  
 If  $17a = \pi$ , prove  $16 \cos a \cos 2a \cos 4a \cos 8a = 1$ .

**TEN BILLION TONS OF COAL.**

The Nenana coal field, Alaska, will be tributary to the Government railroad now under construction from Seward to Fairbanks. Though the coal of this field is lignite and hence of low grade, yet it has great value as a source of fuel and power for Fairbanks and other Yukon placer camps. The field is about sixty miles south of Fairbanks. It is estimated by the United States Geological Survey, Department of the Interior, that the Nenana field contains some ten billion tons of lignite. The Nenana coal field lies in what is known as the Bonnifield region, which also contains some gold placers that have been mined in a small way for the last ten years. This district is described in a report, entitled, *The Bonnifield Region, Alaska* (Bulletin 501), which can be obtained on application to the Director of the Geological Survey, Washington.



## DEPARTMENT OF MATHEMATICS QUESTIONS AND ANSWERS.

Conducted by Herbert E. Cobb,

*Lewis Institute, Chicago.*

For the many mathematics teachers who are entering the profession every year, and for those who after some years of work and study find themselves at times in doubt concerning questions of subject matter, methods, devices to interest pupils, the history, psychology, or bibliography of mathematics, special problems and the like, this department is established. Probably the question that is perplexing some teacher at the present time has been faced and successfully answered by many others.

It is hoped that many will make use of this opportunity, not only to send in questions, but also to furnish replies to questions already published. Brief discussions, from two hundred to three hundred words, of points brought out in the questions will be appreciated. Address all communications to H. E. Cobb, Lewis Institute, Chicago.

## Questions.

1. What is the most effective way of using the blackboard during a recitation in geometry?
2. About what is the minimum number of original exercises in plane geometry that should be required of a tenth grade class which devotes the entire school year to the subject?
3. How much attention should be paid to the check in the solution of equations?

## ARTICLES IN CURRENT PERIODICALS.

*American Botanist*, for November; Joliet, Illinois; \$1.00 per year, 25 cents a copy: "How Plant Food is Formed," Willard N. Clute; "The Wild Flowers of Hawaii," Vaughan MacCaughy.

*American Journal of Botany*, for November; Brooklyn Botanic Garden; \$4.00 per year, 50 cents a copy: "Studies on Exosmosis," S. C. Brooks; "Effect of Environmental Conditions Upon the Number of Leaves and the Character of the Inflorescence of Tobacco Plants," H. A. Allard; "Oenothera Mutants with Diminutive Chromosomes," Anne M. Lutz.

*American Mathematical Monthly*, for December; 5548 Kenwood Ave., Chicago; \$3.00 per year: "Preferential Voting," W. V. Lovitt; "A Direct Proof of De Moivre's Formula," S. Lefschetz; "Sailing to Windward," W. E. Byerly; "The Accelerations of the Points of a Rigid Body," Peter Field and Alexander Ziwet.

*Conder*, for November, December; Hollywood, Los Angeles, Cal.; \$1.50 per year: "Some Results of a Winter's Observations in Arizona," A. Brizier Howell; "Meeting Spring Half Way III," Florence M. Bailey; "More Summer Birds for San Francisco County" (with one photo by O. J. Heinemann), Milton S. Ray.

*Geographical Review*, for December; Broadway at 156th Street, New York City; \$5.00 per year, 50 cents a copy: "The Museum of the American Indian, Heye Foundation" (1 diagram, 9 photos), George H. Pepper; "Geographic Influences in British Elections" (2 textmaps), Edward Kreh-

biel; "The Churchill River" (1 map, 10 photos), Frederick J. Alcock; "The Early Relations Between Newfoundland and the Channel Islands" (1 map), H. W. Le Messurier; "Our Immigrant Problem: A Discussion and Review," Ellsworth Huntington.

*Educational Psychology*, for November; *Baltimore, Md.*; \$2.50 per year, 30 cents a copy: "Tests of Esthetic Appreciation," Edward L. Thorndike; "The Effect of Attitude on Immediate and Delayed Reproduction: A Class Experiment," Joseph Peterson; "A Study of Mental Fatigue with a Group of Five Boys," William T. Root, Jr.

*Journal of Geography*, for December; *Madison, Wis.*; \$1.00 per year, 15 cents a copy: "Tree Crops for Dry Lands," J. Russell Smith; "Economic Aspects of Inland Water Transportation" (concluded), H. G. Moulton; "The Influence of the Lumber Industry upon the Salt Industry of Michigan," C. W. Cook; "The Port of Kobe," Walter N. Lacy; "A Recommended List of Essentials in Place Geography," V. C. Bell, T. M. Davies, H. D. Smith; Current Material for the Geography Teacher.

*Nature Study Review*, for December; *Ithaca, N. Y.*; \$1.00 per year, 15 cents a copy: "Some Plants Mentioned in Shakespeare," Adeline F. Schively; "Mosquito Extermination in New York," G. T. K. Norton; "The Oriole," Anne E. Ash; "The Domestic Cat," "The Cottonwood," G. H. Bretal; "December Nature Study," Anna B. Comstock.

*Physical Review*, for December; *Ithaca, N. Y.*; \$6.00 per year, 60 cents a copy: "The Dielectric Constant of Aqueous Solutions," Elmer A. Harrington; "The Existence of a Subelectron?" R. A. Millikan; The Electrical Conductivity of a Bunsen Flame for Small Distances Between the Electrodes," Norman Hurd Ricker; "On the Mobilities of Gas Ions in High Electric Fields," Leonard B. Loeb; "The Properties of Slow Canal Rays," A. J. Dempster; "A Direct Reading Precision Refractometer with Uniformly Divided Scale," G. W. Moffitt; "On a Modification of the Hilger Sector Photometer Method for Measuring Ultra-violet Absorption and its Application in the Case of Certain Derivatives of Fluorane," H. E. Howe; "The Distribution of Angular Velocities Among Diatomic Gas Molecules," Edwin C. Kemble; "On the Occurrence of Harmonics in the Infra-Red Absorption Spectra of Gases," Edwin C. Kemble; "On the Ionization of Gases by Alpha Rays," H. A. Bumstead; "The Magnetic Properties of Hematite," T. Townsend Smith; "A Redetermination of the Absolute Value of the Coefficient of Viscosity of Air," Ertle Leslie Harrington.

*Popular Astronomy*, for January; *Northfield, Minn.*; \$4.00 per year: "Jupiter in 1915-16" (with Plate I), Latimer J. Wilson; "Man and the Universe," C. M. Kilby; "The Flash Spectrum," Bernard H. Dawson; "The Total Solar Eclipse of June 8, 1918" (with Plate II), Edison Pettit; "The Solitary Star," Maud B. Hunt; "Total Eclipse of the Moon, January 7-8, 1917," William F. Rigge; "William Herschel," Charles N. Holmes; Nineteenth Meeting of the American Astronomical Society (Continued); "The Parallaxes of Procyon and Altair," S. A. Mitchell.

*School Review*, for December; *University of Chicago*; \$1.50 per year, 20 cents a copy: "Fundamental Considerations in the Reorganization of High-School Science," Fred. D. Barber; "Supervised Study in the Everett High School," Alexander C. Roberts; "The Result of Supervised Study in the Houghton, Michigan, High School," John E. Erickson.

*School World*, for December; *Macmillan and Co., London, Eng.*; 7s 6d per year: "Left-Handedness," P. B. Ballard; "Clearing the Ground for Educational Reform," Beta Dash; "A Thirteenth-Century Fragment of Euclid's Elements," Rev. Canon J. M. Wilson; "An Engineer's Views on Education" (from the Presidential Address to the Institution of Automobile Engineers), L. A. Legros.

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## SCIENCE QUESTIONS.

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*University School, Cleveland, Ohio.*

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your first term or mid-year examination papers now.

## Questions and Problems for Solution.

249. *Proposed by John C. Packard, Brookline, Mass.*

What effect do high altitudes have on the power of a steam engine? Modern Geography, by Salisbury and Others. Get a Denver man to answer from practical experience or perhaps a rocky mountain miner or prospector.

250. *From "Chemical Calculations" (Van Nostrand) by R. Harman Ashley, Ph. D.*

If the volume of the moon is  $\frac{1}{49}$ th and its mass  $\frac{1}{81}$ st that of the earth, (a) what is the density of the moon compared to the earth? (b) If the relative density of the earth is 5.53, what is the relative density of the moon? *Ans.* (a) 0.605; (b) 3.34.

251. The question has been asked the Editor—"Why are not Botany examinations printed in this department?" In answer is given the following Botany examination.

What would Botany teachers like to see in these columns?

*Brown University Examination for Admission,  
Botany, September, 1916.*

1. Make a diagrammatic drawing of bean seed showing the main structural parts and state briefly but concisely the function of each.
2. Name the most important elements which are the sources of food for green plants.
3. Distinguish between monocotyledonous and dicotyledonous stems. Illustrate by diagram.
4. Through what organs does water enter a higher plant? Trace a molecule of water from its place of entrance into a plant to a cell in the palisade layer of a leaf.
5. What are Stomata? In what part or parts of a plant do they occur? State briefly their function.
6. How may fungi be distinguished from ordinary plants? Are fungi of any economic importance? Reasons for your answer.
7. What is meant by Photosynthesis? Does it occur in all the cells of a plant? Reasons for your answer.
8. What is a Lichen? Illustrate structure.
9. What is a perfect flower? An irregular flower? An inflorescence? A gamopetalous flower? The perianth? A simple leaf? Compound leaf?
10. Mention two ways by which a Moss plant reproduces. Are mosses of any economic importance? Reasons for your answer.

Please answer questions numbered 252 and 253 from the examination paper that follows.

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*Massachusetts Institute of Technology—Sept., 1916.*

*Physics.—Time: Two hours.*

1. Explain, in concise and exact language, the distinction between motion and momentum; force and power; acceleration and velocity.

2. A body is hung from the ceiling of an elevator by a spring balance. If the elevator ascends from rest would there be any change in the reading of the spring balance, and if so, what? Explain why lead bullets and bits of paper fall with the same velocity in vacuum.

252. A plank 20 feet long, weighing 200 pounds, rests on a flat roof with 8 feet of its length projecting beyond the edge of the roof. If a keg of nails weighing 100 pounds rests on the inner end, how far out on the plank may a man weighing 180 pounds go without tipping?

4. A body weighing 20 pounds falls freely for 4 seconds. Calculate (a) distance traversed, (b) velocity acquired, (c) final energy due to its motion.

5. Explain in detail why a shotgun "kicks." What factors affect this "kicking"? Why does a stove "draw"? Explain why thermos bottles retain heat.

6. Why does the quality of a violin note differ from that of a cornet note of the same pitch and loudness? What is an overtone? What are "beats"?

7. Ten incandescent lamps are connected in parallel across mains between which a pressure of 110 volts is maintained. If the resistance of each lamp is 60 ohms, how much power are they using? What current would flow if they were all in series?

253. How far from a screen must a 100 candle power lamp be placed to give the same illumination on the screen that a 40 candle power lamp 5 feet away would give? What is meant by principal focus; optical center; index of refraction and conjugate foci?

## Solutions and Answers.

238. *Comments are requested on the following set of physics questions, constituting the paper set by the College Board in June, 1916.*

Is it too long? [Time allowed was two hours.]

Is it too difficult? [Should the average of instruction in good schools be the standard or the best instruction in the best schools?]

*Comments by P. C. Hyde, Newark Academy, Newark, N. J.*

Out of twenty-six students completing Physics in Newark Academy last June, twenty-two took this examination; all but one of them were third year students. Judging by the time taken and the results obtained, the examination would seem neither too long nor too difficult, taken as a whole. Several questions, however, are open to criticism.

Question 2 is easy enough, if pupils have had a few of that peculiar type; but the type is one that no teacher would be likely to use unless working with certain ancient Harvard papers or with a particular problem book. To a pupil with a natural training the problem is merely fantastic and confusing.

Question 5 is deceptive. Was it an attempt to disguise a numerical problem? Very few pupils indeed but would find an answer with actual numbers easier.

Question 8 (No. 240) is preposterous. It is difficult to imagine a more effective means of rendering Physics barren and irksome than burdening it with problems involving assumptions that are manifestly absurd. The mechanical equivalent of heat touches the every day experience of our pupils in the most natural way in connection with electrical heating devices; even there it is carefully concealed in the .24 that we find unexplained in most textbooks. See question 15.

Question 9 is of course unsolvable except on the assumption of constant volume, which is at least questionable.

Question 11 (No. 241). Couldn't this have been stated in terms that didn't require defining on the paper, or was it put this way to make it look hard?

239. *From a Board examination.*

When supplied with 100 cubic feet of water per second, at a head of 45 feet, what horse power is developed by a turbine water wheel having an efficiency of 80 per cent? (One cubic foot of water weighs 62.4 pounds.)

*Solution by J. P. Drake, Emporia, Kansas. Also solved by Elvira Weeks, Cloquet, Minn., and P. C. Hyde, Newark, N. J.*

$100 \times 62.4 \times 45 = 280,800$  ft. lbs. lifted per sec. if pump were 100 per cent efficient.

$280,800 \times .80 = 224,640$  ft. lbs. per sec. (efficiency 80 per cent)

$224,640 \div 550 = 408.4$  H. P. *Ans.*

240. *From a Board examination.*

A steel projectile is moving with a speed of 700 meters per second at the instant that it strikes a target. Assuming that all of the energy of motion is transformed into heat in the projectile, calculate its rise of temperature. Take the specific heat of steel at 0.12 and the mechanical equivalent of heat at 41,800,000 ergs.

*Solution by Elvira Weeks, Cloquet, Minn. Also solved by P. C. Hyde and J. P. Drake.*

K. E. =  $\frac{1}{2}mv^2$ . Let  $m = \text{unity}$ .

K. E. =  $\frac{1}{2} \times (70,000)^2 = \frac{1}{2} \times 4,900,000,000 = 2,450,000,000$  ergs.

41,800,000 ergs = 1 calorie.

$\therefore 2,450,000,000 \text{ ergs} = \frac{2,450,000}{41,800} = 58.61 \text{ calories.}$



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.12 calories raise 1 gm. steel 1° C.

∴ 58.61 calories raise 1 gm. steel  $\frac{58.61}{0.12} = 488.5^\circ \text{C.}$

241. *From a Board examination.*

If the illumination necessary for reading is 2 foot candles, how far away from a reader may a 16 candle-power lamp be placed? (One foot candle is defined as the intensity of illumination produced by a source of light of one candle power at a distance of one foot from that source, the light falling perpendicularly.)

*Solution by P. C. Hyde, Newark Academy, Newark, N. J. Also solved by J. P. Drake, and Elvira Weeks.*

$$\frac{D^2}{1^2} = \frac{16}{2} \quad D = 2\sqrt{2} = 2.83 \text{ feet.}$$

For equal intensities, the candle powers vary directly as the squares of the distances.

## Correction.

*Correction by Henry V. Hesselbach, Cooper Union, New York City. Also noted by P. C. Hyde, Newark Academy.*

In glancing over the solution of problem No. 2 on page 838 of the December number of SCHOOL SCIENCE AND MATHEMATICS I found it to be entirely incorrect. The very last two lines on page 838 show the fallacy in the solution, for the mechanical advantage can only be used in raising the weight of 1,800 lbs. and not in the force of friction along the beach or plane.

Permit me to submit the solution as I understand the problem.

Total force ( $F_t$ ) = force due to gravity ( $F_g$ ) + force due to friction ( $F_{fr}$ ).

$$F_t = F_g + F_{fr} \text{ (for uniform motion).....(1)}$$

$$F_g = \frac{3}{10} \text{ 1800 force of gravity.}$$

$$= 540 \text{ lbs.} \dots\dots\dots (2)$$

( $F_{fr}$ ) force of friction =  $P_n$  when  $P_n$  = normal pressure. .... (3)

$$\text{But } \frac{P_n}{W(1800)} = \frac{\text{Base and since base} = 9.5 \text{ ft.}}{10}$$

$$\text{we have } P_n = 1800 \frac{9.5}{10} = 1710 \text{ lbs.}$$

$$\text{and } \therefore (3) - F_{fr} = 0.4 \times 1710 = 684 \text{ lbs.}$$

hence from (1)

$$F_t = F_g + F_{fr} = 540 + 684 = 1,224 \text{ lbs.}$$

1,224 lbs. is the force required instead of 756 lbs. as stated on page 838.

With the block and tackle arrangement the answer of the problem should be  $\frac{1,224}{6}$  or 204 lbs. against 126 lbs.

6

Surely, this problem would offer considerable difficulty to even the best pupil. I wonder how many candidates solved the above problem correctly?

#### TEACHERS ARE NOT LABORERS.

A great deal has been said recently concerning the legal status of teachers' agencies, as to whether they come within the bounds of those organizations which are obliged to pay license fees in order to do business. There are certain parties who contend that the instruction of children is placed on the same ground with the person who digs in the ditch, or lays brick, or cleans a street, or anything else of a similar character. But in a recent decision handed down by the attorney-general of the state of Missouri we note the following:

"The word laborer is ordinarily understood to apply to one working with his hands or engaged in physical employment. The word labor, when employed to represent a class, is commonly understood to mean those working with their hands or engaged in physical toil. An examination of lexicons as well as adjudicated cases shows this interpretation to be correct."

The same decision quotes from other authorities in order to substantiate this interpretation of the word laborer.

The decision of the department is that a teachers' employment bureau does not come within the provisions of Article 2 of Chapter 67, Revised Statutes of Missouri, 1909. Therefore such agencies are not required to be licensed in order to transact business.

#### GEOLOGICAL SURVEY HAS WIDE SCOPE OF ACTIVITIES.

One of the results of the work of the Geological Survey, Department of the Interior, that is prominently before the public is seen in the topographic maps issued by the Survey. Large areas of the country have been mapped, including some entire states and aggregating nearly half of the United States exclusive of Alaska, much of which has also been surveyed, and the Geological Survey has now published over 2,500 separate topographic maps. These maps are being much more generally used than formerly, as their value for many purposes is coming to be recognized. For instance, the automobilists, who are purchasing thousands of maps annually, find them valuable in tracing road routes, and now aviators who are making long-distance flights are using them. During the last fiscal year, according to the *Thirty-Seventh Annual Report of the Director of*

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the Geological Survey, there was an increase in the sales of these maps amounting to seventeen per cent. The distribution during five months of the present fiscal year indicates that this percentage of increase will be much exceeded, the demand for topographic maps by citizens of all classes being far greater than ever before.

The topographic surveys made during the year covered 22,716 square miles, more than the total area of Massachusetts, Connecticut, and New Hampshire. In addition, areas amounting to 10,412 square miles were topographically surveyed in Alaska.

The Geological Survey also made geologic surveys, both detailed and reconnaissance, covering 43,662 square miles in forty-seven states, the Canal Zone, and the West Indies, and an additional 10,900 square miles in Alaska.

The investigation of water resources is one of the important activities of the Geological Survey. The volume of streams was measured during the year by hydraulic engineers at 1,677 stations in thirty-nine states, Alaska, and Hawaii.

The Geological Survey classified during the year 43,000 acres of public land as to its mineral character and 188,000 acres as to its value for power sites or public water reserves—springs or water holes. It also classified 27,254,442 acres in the Western States as nonirrigable and subject for designation under the enlarged homestead laws.

The scientific and economic reports of the Geological Survey for the year aggregated nearly 20,000 printed pages, and over 603,000 copies of these and other reports were distributed, besides 620,000 copies of geologic folios and topographic maps.

The Geological Survey is coming to be recognized more and more as a clearing house of information on the mineral resources of the United States. During the year correspondence was carried on with 92,000 mineral producers, including some in every state, and thousands of letters were written to the general public, covering every conceivable question concerning minerals and mineral products.

# Announcement



Owing to the extraordinary increase in the price of practically everything entering into the cost of living and operating a business, this Journal finds itself confronted with fresh problems to solve. The price of print paper, of the quality and kind which we have been using heretofore, has increased nearly three-fold over that which we have been paying. There are open to us three methods of solution.

We can use an inferior quality of paper, reduce the size of magazine as far as pages are concerned or else increase the subscription price. It is our policy to maintain the mechanical quality of the Journal equivalent to its educational worth, therefore the most feasible solution from our point of view is to increase the subscription rate to \$2.50 per year. Something must be done. We are therefore asking our readers for advice as to which of the three propositions named will best meet their approval.

It is not our desire to increase the subscription rate and trust we will not be obliged to do so.

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## BOOKS RECEIVED.

One Hundred Exercises in Agriculture, by John H. Gehrs, Normal School, Warrensburg, Mo., and J. A. James, University of Wisconsin. Pages xi+222. 20x26 cm. Paper. 1916. The Macmillan Company, New York City.

Modern Business Arithmetic, by Harry A. Finney, Walton School of Commerce, Chicago, and Joseph C. Brown, Normal School, St. Cloud, Minn. Pages vi+488. 15x21 cm. Cloth. 1916. Henry Holt & Company, New York City.

Outlines of Physiology, by Edward G. Jones and Allan H. Bunce, Emory University. Pages xvi+373. 13x19 cm. Cloth. 1916. \$1.50 net. P. Blakiston's Son & Company, Philadelphia.

Lessons in Physics—Teachers' Edition, by Herbert Brownell, University of Nebraska. 139 pages. 15x22 cm. Cloth. 75 cents. Torch Press, Cedar Rapids, Iowa.

Five Hundred Practical Questions in Economics, by a Special Committee of the New England History Teachers' Association. 58 pages. 125x18.5 cm. Paper. 1916. 25 cents. D. C. Heath & Company, Boston.

Laboratory Manual of Chemistry in the Home, by Henry T. Weed, Manual Training High School, Brooklyn, New York. 200 pages. 19x24 cm. Paper. Loose leaf. 1916. American Book Company, New York City.

An Introduction to Astronomy, by Forest Ray Moulton, University of Chicago. Pages xxli+577. 14x20 cm. Cloth. 1916. \$2.25. The Macmillan Company, New York.



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## BOOK REVIEWS.

*Elementary Algebra*, by George W. Myers, University of Chicago, and George E. Atwood, Newburgh, New York. Pages xii+338. 14x20 cm. 1916. Scott, Foresman & Company, Chicago.

This book has for its most pronounced characteristic an insistence upon a rational conception of algebra. It is, of course, hardly possible to get rid entirely of memory work in the teaching of algebra. For certain minds the act of memory is so much easier than that of reasoning that the effort of memory is practical in the operation of the reasoning faculty. A book therefore which has a tendency to diminish the numbers in this class, as this book tends to do, is surely deserving of a welcome.

The book is not radical and follows quite generally the traditional treatment, and yet it is most distinctly not a book to be used in a mechanical or half understanding sort of way. It is therefore a book that would appeal to the discriminating teacher who is not satisfied with the results obtained by the use of more conventional texts. The explanations are lucid, thorough, and exact; the problems are numerous, and are selected and arranged in a fashion to enforce a sure development of the idea just explained. The early introduction of the function idea, its immediate application to the solution of equations, and the use of the graphical solutions to explain simultaneous equations, rather than to serve as more or less heavily connected ornaments of the subject, all have a tendency to lay emphasis on understanding rather than on mechanical ability.

The chapter, "General Numbers—Formulas—Type-Forms," is the best treatment of this subject that the writer has seen. Another good feature is the attention given to symbolism or interpretation of algebraic language and the idea that algebraic expressions are representations of numbers.



Worthy of note is the introduction to the subject in "Reasons for Studying Algebra." This, which is a sort of preface, is a well-written apology for algebra which will appear to many teachers as representing what they have already felt.

The "Summary of Definitions" at the end of the book gives promise of being workable and a great convenience. The problems show as great an aspect of practicability as is possible in elementary algebra. Their number is ample, and their difficulty seems well graded. The typographical arrangement is pleasing and effective. All told it is a well-written, well-arranged, well-printed book, which seems to hold the purpose of algebra in school work constantly in view.

CHARLES W. NEWHALL.

*Fundamentals of Botany*, by C. Stuart Gager. Pages xix+640. 13½x19½ cm. 1916. P. Blakiston's Son & Company, Philadelphia.

The typical textbook of botany for secondary schools consists of a first part devoted to the general phenomena of plant life and illustrated principally by flowering plants, a second part dealing with life histories, and a third part in which are assembled such economic and ecological materials as have not been assimilated to the body of the text. There is evident an increasing tendency to treat the economic and ecological materials in the first part of the text rather than to assign them to final chapters. The physiological viewpoint comes more and more to dominate the presentation, particularly in the general discussion of plant life. The organization, however, has remained strictly morphological. The division into chapters treating respectively root, stem, and leaf may be traced from the time of *Gray's Lessons* down to date. The book under review is probably the first elementary text to organize the general discussion of plant life upon a physiological basis.

Part II of the book is composed of chapters on "Loss of Water," "Absorption of Water," "Path of Liquids," "Nutrition," "Fermentation," "Respiration," "Growth," "Adjustment to Surroundings." It will be noted that these chapters are primarily physiological. The anatomy of the organs concerned is treated, but anatomy is subordinate to physiology rather than dominant. The reviewer believes that this treatment represents a coming phase of elementary botanical instruction, and that the appearance of a textbook containing a treatment of the general facts of plant life with such a thoroughly physiological viewpoint is an event of importance. Whether the particular details of treatment here presented will be finally accepted by common consent it is now too early to say, but the book is most suggestive and should be known to every teacher of high school botany.

Part I is introductory. Part III takes up the structure and life histories of plants, combining with this a considerable amount of economic and physiological material, as in the chapter on fungi. The last eight chapters of this part treat of such topics as evolution and heredity. They might very well constitute a fourth part, to be designated as philosophical botany.

The discussion in Part III will be found to be rather heavy work for high school use, if the course is given in the first or second year, as is commonly the case.

A laboratory manual is announced.

W. L. E.

*Lessons in Physics—Teachers' Edition*, by Herbert Brownell, University of Nebraska. 139 pages. 15x22 cm. Cloth. 75 cents. Torch Press, Cedar Rapids, Iowa.



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*How to Use Your Mind*, by Harry D. Kitson, University of Chicago. 216 pages. 13x18.5 cm. Cloth. 1916. \$1.00 net. J. P. Lippincott Company, Philadelphia.

A book worthy to be read and studied by every person who wishes to make his life as efficient as possible. It is a volume especially adapted for students, in order that they may get their minds so trained to action that they will be enabled to do their school or university work with the least possible waste of time, money, and energy. We are just beginning to appreciate the fact that it is just as much of a science to know how to think, and act, and use our minds as it is to be conversant with the facts and theories of physics in order to be a good research physicist. This book ought to be possessed and read by every college and university student. It surely deserves an extensive circulation. It is printed in a large, heavy-faced type on rough paper, thus reducing the glare of the reflection of light to a minimum. C. H. S.

*The Psychology of Drawing*, by Fred C. Ayre, University of Oregon. Pages ix—186. 13.5x20 cm. Cloth. 1916. \$1.25. Warwick & York, New York.

Evidently the author of this book believes in the efficacy of proper drawings, not only in the interpretation of results, but as a method of retaining information which has been worked out in the laboratory, field, and class-room. It is a book which all instructors of laboratory sciences in which drawings should be made of material and apparatus studied, should make use of for themselves in order that they may make their instruction more efficient. The plan of presentation is admirable. The literary style is almost above criticism. The volume stands almost alone in this field, and its author deserves every commendation that can be given him for working out these theories which are so helpful for the study of every laboratory science. C. H. S.

*Elementary Economic Geography*, by Charles R. Dryer. 415 pages. 14x20.5 cm. Cloth. 1916. American Book Company, New York.

A book which deserves the widest circulation among all people who are interested in geography. This particular phase of geographical study meets a demand. The author is a past master in the art of teaching geography. Nearly every phase of geographic work, as far as its economy for mankind is concerned, is mentioned in the book. It is splendidly written and profusely illustrated with pictures and drawings that have been selected with the greatest care in order that they may present at a glance the matter that has been discussed in the paragraphs connected with them. The major paragraphs are titled, the titles being printed in bold-face type. There are thirty-three chapters in the text. The volume confines itself practically entirely to the resources of the United States. There is a complete index appended, and at the end of every chapter there are given lists of practical questions bearing upon the work discussed in that chapter. It unquestionably is one of the best books on the subject ever printed, and should be in the hands of every instructor of geography. C. H. S.